Better Crops

WITH PLANT FOOD

January - February, 1960

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A Special Issue on LIMITING FACTORS IN CROP PRODUCTION

An Introduction

By Sterling B. Hendricks

RECIPIENT OF THE PRESIDENTIAL AWARD FOR DISTINGUISHED CIVILIAN SERVICE

WHEN you stop to realize that the estimated *net increase* of our population is five human beings each minute, 300 each hour, 7,200 each day, it is not difficult to believe that the United States alone will have more than 200 million mouths to feed in 1975—just 15 years from now.

Agriculture's big job is to *maintain* its ability to feed this rapidly growing population. This cannot be done by increasing cultivated area. Good land is limited and is decreasing as non-agricultural uses encroach. Adequate future food supplies will demand practices that are efficient enough to keep our yields in line with our needs. To do this, we must eliminate or control what the agricultural scientist calls "limiting factors in crop production" —and what the Missouri farmer might call "those dang borers and that sorry poor soil."

We must remember there is a limit to performance—whether it's the human sprinter covering 100 yards in little less than 10 seconds or the bottomland corn yielding 300 bushels per acre. Most things increase less and less rapidly as effort is stepped up and a ceiling is approached. Crop production is no exception. A look at crop production in terms of the yield curve shows why. The yield curve in crop production has three parts: (1) A toe where things are getting under way, (2) A straight part in the center or the region of linear response, (3) And the inevitable bending over or leveling off.

In the *linear response* region (the straight moving-up area), you can increase yields by increasing efforts. The average yield is often just above the center of the curve where there is plenty of room to move up under the ceiling. Here the next amount of fertilizer or pest control you apply can often be as profitable as the last one. But, finally, further changes may become unprofitable or the risk too great.

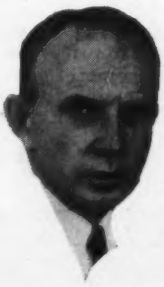
When you reach the upper part of the curve, the only way out is through the ceiling. For example: the average yield of cotton per acre is about a half bale in Texas, one bale in Mississippi, and two bales in California. These yields range from half to two-thirds the way to the present ceilings. In California, all the limiting factors may possibly be in sight and under best conditions the ultimate potential of the cotton plant as we know it today might be realized.

But in Mississippi, and even more so in Texas, certain factors may be limiting the full potential of our modern cotton plant. It may be climate or infestation by pests or insufficient nutrition. In any event, when a limiting factor is found and *altered* (for example, by increasing water supply or introducing a disease resistant variety) the old factors that had given their maximum response should be re-examined and a new curve established. The *average* yield on this new curve (falling on the linear region) might then equal the *maximum* yield on the old curve—that is, *after* the limiting factor has been met and altered, the farmer's average yield might equal or top the maximum yield he was getting while his crop was struggling along with inadequate nutrients or too little moisture or inadequate pest control, etc. Then, he can still profit by increasing an already high level of fertilizer application or by boosting the number of plants per acre.

With limiting factors under control, what, then, is our potential in the United States? Wheat production in Denmark, for whatever reasons, is *double* the 28 bushels per acre of Maryland on closely the same acreage. This *factor of two* (two times as much) is a conservative and realistic estimate of America's *potential.* A 2.5-fold increase would be much more difficult. Three times the Denmark production might be impossible. In the end, there is an "impossible" for productivity.

Although we can now control and remove many limiting factors, new and serious ones might arise to thwart our efforts to feed an ever-growing population. Erosion, decreases in native fertility, increases in salinity, and dissipation of concentrated sources of plant nutrients—all these factors hover over us, some caused by usage, others controlled by careful effort. Our challenge is to be always at work overcoming them so we can meet our potential needs.

~



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ON THE COVER

. . . we treat in cartoon fashion many of the factors that can pull down a farmer's yields and profits. They are hard at work on the yield curve in crop production, pulling it down, down, down. And with it, pulling down dollars and dollars of profits. Weeds, diseases, insects, inadequate plant food, poor stands, water problems. The farmer faces them every day. In this special issue, some experts in agricultural research and education take a realistic look at these factors and some ways to combat them.

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Farmers everywhere reporting . . .

"AN EXTRA LOAD OF CORN FROM EACH BUSHEL OF FUNK'S-G PLANTED"

Gerald Bond

1959 Weigh and Compare results show Funk's-G users continue to harvest an extra wagonload of corn from each bushel of Funk's G-Hybrid seed they planted. Funk's G-Hybrids are maintaining their 5 to 15 bushel per acre yield advantage over other hybrids.

Weigh and Compare tests are yield comparisons made by farmers who want to find out for themselves which hybrids perform best on their farms.

Gerald Bond, New Castle, Indiana, farmer, has Weighed and Compared hybrids the past 5 years. Here is what he says about them. "A man just can't tell which hybrid is making him the most corn if he doesn't weigh it. I'm sure the weighing has made us over $5,000 for our time over the past 5 years. Of course, it takes time to haul 6 or 8 loads 5 miles, but how else will you know which hybrid to plant? Funk's-G has topped our tests every year and has been planted with over 15 different competitive numbers."

FUNK'S G HYBRID

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Consistently Good, Year after Year
THE PRODUCERS OF FUNK'S G-HYBRIDS

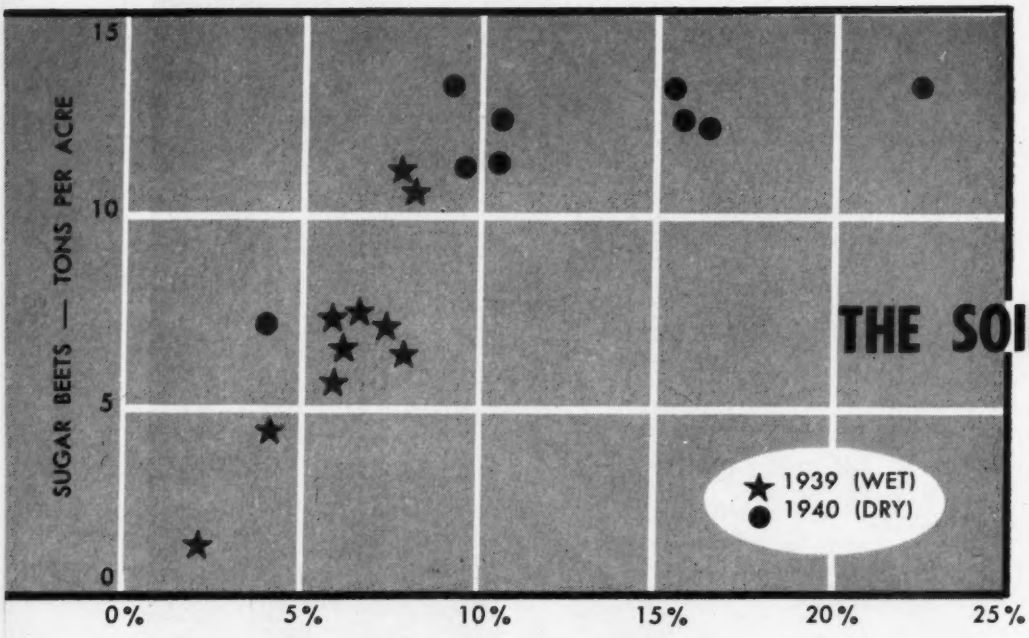


Figure 1—This shows the relation of non-capillary porosity (large soil pores) and sugar beet yields in Pauling clay during a wet (1939) and a dry (1940) July and August in Ohio. Note how beet yields were affected by the increased percentage of large soil pores. (Information from L. D. Baver and R. B. Farnsworth, Soil structure effects in growth of sugar beets. Soil Sci. Soc. Amer. Proc. 5:45-48 1940)

THE PHYSICAL characteristics of the soil may greatly influence the maximum yield of a crop on a given piece of land. This is because the *physical properties* of the soil affect many things that regulate crop growth, either directly or indirectly.

For example, the physical properties of the soil regulate:

1 The intake and flow of water.

2 Available moisture storage capacity.

3 Movement of air and heat.

4 Mechanical impedence to root development and seedling emergence.

5 The ease with which the soil can be tilled.

Nutrient uptake is influenced by moisture supply, aeration, and temperature and the ability of roots to grow into those parts of the soil where there is an available supply of nutrients and water.

Toxic substances may be produced in the soil due to certain physical factors.

YOUR SOIL HAS PORES

The flow and storage water, movement of air and transfer to heat in the soil depend on size, shape, continuity, and existing moisture content of the soil pores. These soil pores are the

IL PHYSIQUE..... .....OR PHYSICAL FACTORS IN YOUR SOIL

By R. B. Alderfer

Rutgers University

openings that occur between the solid particles of the soil.

There are two size classes of pores found in soils:

Large Pores

1 The *large pores,* often called non-capillary pores, are not able to hold water tightly by the process called capillarity. In well drained soils they are the first to lose water by gravity after a rain or an irrigation. But they are needed for rapid intake and ready percolation of water through the soil. Air is drawn into them as soon as water is drained from them. They might be looked upon as the *air condition'ng ducts* in the soil.

Small Pores

2 The *small pores,* called capillary pores, are responsible for the water-holding capacity of soils. The ideal soil should have the pore space about equally divided between large and small pores. Such a soil should have enough aeration, permeability, and water-holding properties. Unfortunately, not all of our agricultural soils have this proportion of large and small pores.

For example, *very sandy soils* have too few small pores which causes their low water-holding capacity. On the other hand, many soils have too few *functional large pores* throughout the profile or in some part of the surface

Dr. Russell B. Alderfer is chairman of the Soils Department at Rutgers University. He is well known for his research on how soil management practices affect the physical condition of the soil and how soil physical condition influences crop production. He is the author of many bulletins, scientific and popular articles in this field.

soil or the subsoil. Compact layers in the soil often have very few large pores, which causes low permeability to water. Air movement is restricted if the pores remain filled with water.

Figure 1 shows the effects of varying amounts of *non-capillary porosity* on crop yields and on the infiltration and runoff of water in pastures.

SOIL AGGREGATION AND STRUCTURE

The shape and number of different-sized pores in your soil is determined by the size, shape, and arrangement of the *soil particles*. Both the texture and structure of the soil have much to do with the nature of the pore space.

Soils with fairly large amounts of silt and clay have many of these fine particles grouped into structural units called *aggregates*. The number, size, shape, and arrangement—particularly the amount of overlap—of the soil aggregates largely determines the kind of pores found in soils with large amounts of silt and clay.

The degree of aggregation, particularly in the tilled layer, varies a great deal, depending on the *texture* and *organic matter content* of the soil and also on *climatic conditions* and *cultural practices*.

Your soil and crop management practices should produce and retain a structure needed to provide for proper movement of air, water, and heat and the growth of roots through the soil.

Excessive tillage, especially when the soil is too dry or too wet, machinery and foot traffic, raindrop impact, failure to add organic matter to the soil, and salt accumulation can cause poor physical condition, largely through bad effect on the aggregation of the soil.

YOUR SOIL'S PHYSICAL CONDITION AFFECTS YOUR PLANT GROWTH

The physical condition of your soil may affect plant growth directly or indirectly, from seeding through the whole life of the plant. Failure to get top yields is often caused by too low a plant population due to poor germination or seedling emergence.

Soils with too many large, hard clods are difficult to work into a seedbed that has enough soil in contact with the seed for rapid germination and seedling growth.

A *good seedbed* should consist of aggregates between *1* and *5 millimeters in diameter*. A hard, dry surface crust may reduce seedling emergence more than 50%. Compaction (hardening) of the soil surface by raindrop impact or by trampling reduces the infiltration of water.

The aeration of the soil (its ability to get air) is also affected whenever the compacted layer remains saturated with water, because air movement through water-filled pores is very slow.

Several practices are used to correct or minimize soil compaction, including cultivation of row crops to break up surface crusts, aerification of compacted turf soils, mulch tillage, and minimum tillage.

The chance of getting top yields is much better most of the time, if the roots of the crop plant are able to keep growing without encountering any soil layers that impede or alter the normal development and functioning of the root system.

Tillage pans and plow soles will often impede or alter root development. So will clay pans and hardpans

in the subsoil. Roots are not able to grow into or through these pans because they resist penetration or aeration (air availability) is too poor.

Such conditions often limit the rooting depth of the soil so much that the available water-holding capacity of the soil above them is so small that crops suffer water deficiency after a brief period of dry weather.

Water moves through these "pan" areas so slowly that the soil above them remains saturated for considerable periods during wet weather or after a heavy rainfall or irrigation. This creates aeration problems so common to imperfectly and poorly drained soils. Breaking the shallower pans when they are dry by subsoiling or chiseling has helped at times.

Attempts to increase the rooting depth of soils by loosening tight subsoils and fertilizing them have not been too successful in most cases. Aeration is regulated by amount of non-water filled pores in the soil. This is why water logging of any soil layer greatly influences aeration.

AERATION AND TEMPERATURE

The importance of soil aeration and soil temperature on plant growth is widely appreciated. Most evidence on the effects of aeration and temperature has been obtained from *culture solution* and from *greenhouse pot studies.* Nutrient and water absorption are affected by too low a supply of oxygen or too high a concentration of carbon dioxide around the plant roots.

Soil Aeration

Aeration can affect nutrient availability and the presence of toxic concentrations of certain elements and compounds by its influence on microbial activity and on the occurrence of oxidizing and reducing conditions in the soil.

Good aeration increases the rate of mineralization of organic nitrogen. Poor aeration conditions increase the amount of the more soluble, reduced forms of iron and manganese.

Soil Temperature

Soil temperature affects plant roots in a number of ways. The growth and functioning of roots are restricted by too high as well as too low a soil temperature. Plants differ in their temperature requirements. Cool-season crops have a lower optimum soil temperature than do the warm-season crops.

Water absorption is restricted at temperatures below the optimum for any plant root, because root elongation is retarded and water movement in the soil and into the root is restricted.

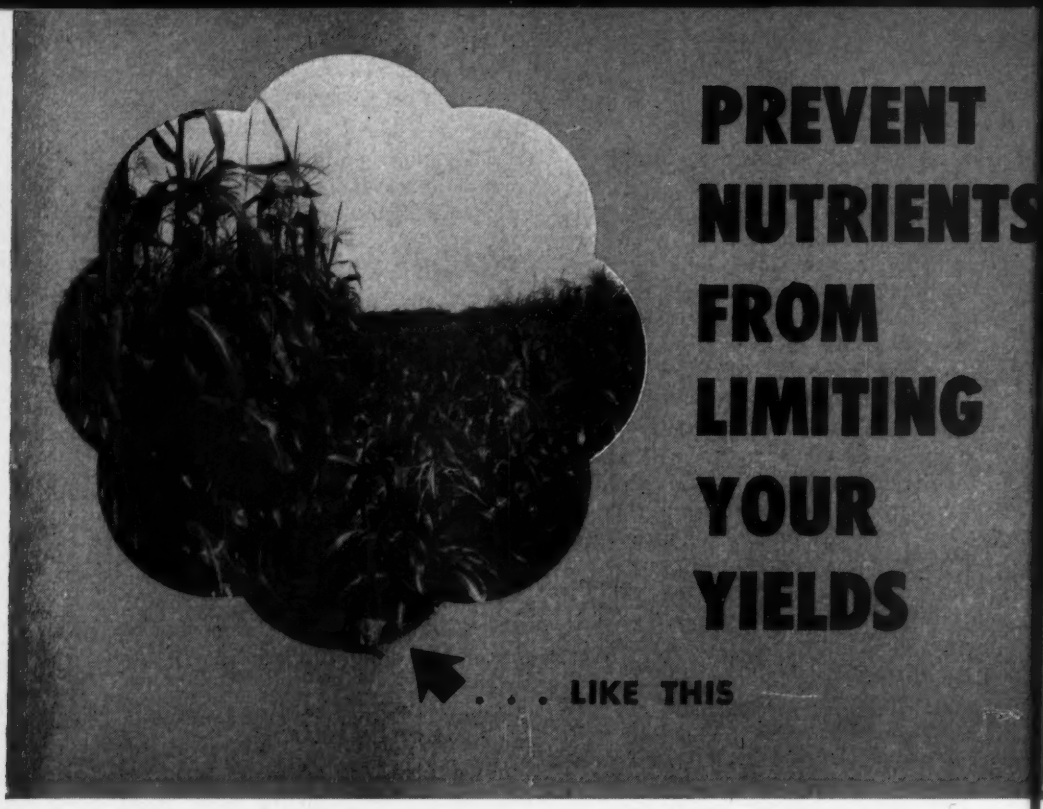
Many investigators have found that nutrient absorption is reduced at low temperatures. But we are not sure whether the reason for poor plant growth in cold soils is due to failure of the roots to absorb nutrients or to the inability of the plant to assimilate the nutrient if it is absorbed.

Temperature greatly influences microbiologieal activity in the soil. Organic matter decomposition and nitrification, for example, are very much slower at low temperatures than at high temperatures.

Since surface cover, color of the surface soil, and moisture content influence the absorption and flow of heat in the soil, mulching, organic matter content, and drainage affect soil temperature.

Thus physical factors do play an important role in regulating the productivity of the soil. Farmers and gardeners who are fortunate in having soil with good tilth or physical condition can count this as a very real asset. Those who are not so fortunate shall always run the risk of this being their most serious limiting factor.

THE END



IN THIS day of high costs and narrow profit margins in farming, top yields are usually a *must.* If you aren't getting just about all your soil and crop will deliver, you are not producing efficiently—and probably not too profitably.

To get top yields, you must properly manage the nutrient supply your crop receives. Not too little. Not too much. But enough for top yields. Inadequate plant nutrients can be one of your most limiting factors.

All required nutrients must be available in sufficient quantities at the *time* and *place* that the plant needs them so plant growth will not be restricted. The type of crop you grow generally affects the total nutrients needed.

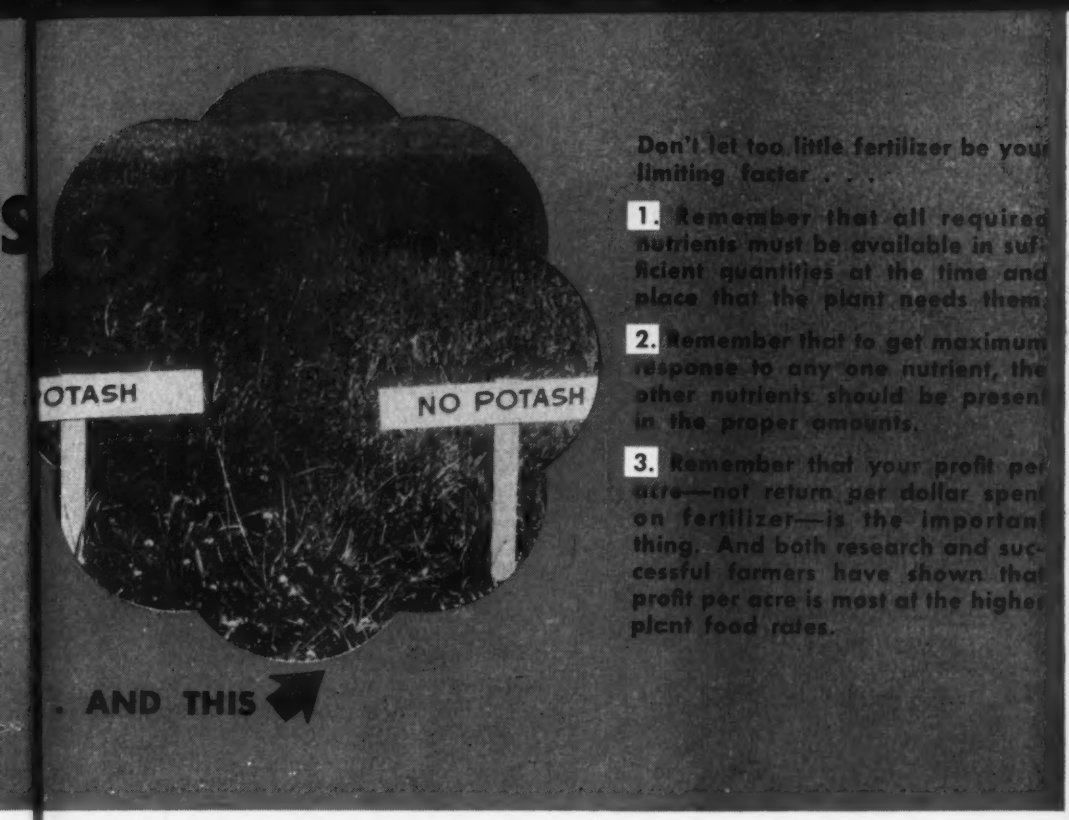
THE SOIL—A SELF FEEDER

Many soils can store adequate amounts of lime, phosphorus, and potassium, releasing them to the growing crop each day as it needs them. What the crop does not use remains for future crops to use.

Once the soil has been brought up to a high fertility level, you add only enough fertilizer to maintain sufficient supply for the plant to get the nutrients easily.

Lime is generally applied on the self-feeder basis.

In many instances, phosphorus and potassium may be efficiently applied by the self-feeder procedure. Once


OTASH
NO POTASH
. AND THIS
Don't let too little fertilizer be your limiting factor . . .
1. Remember that all required nutrients must be available in sufficient quantities at the time and place that the plant needs them.
2. Remember that to get maximum response to any one nutrient, the other nutrients should be present in the proper amounts.
3. Remember that your profit per acre—not return per dollar spent on fertilizer—is the important thing. And both research and successful farmers have shown that profit per acre is most at the higher plant food rates.

the soil or self-feeder is full, you only add enough to keep it full.

Nitrogen must be applied for each crop as needed, since it is not readily stored in the soil.

THE FERTILIZER RESPONSE CURVE—FIGURE 1

As you increase nutrient amounts your yield increases in *curvilinear fashion* shown by the heavy line in figure 1.

The top possible yield is determined by the factors that limit it (*climate, water, etc.*).

Profit from fertilizer may be considered in one of two terms: (1) *return per dollar invested in fertilizer* or (2) *return per acre*. The straight line at bottom of figure 1 shows fertilizer cost in terms of yield.

The return per dollar spent on fertilizer is greatest at low rates. But the *profit per acre* is most at the higher rates where the two lines are furthest apart.

Since most farmers have a limited acreage, they are generally more interested in the profit per acre from higher rates.

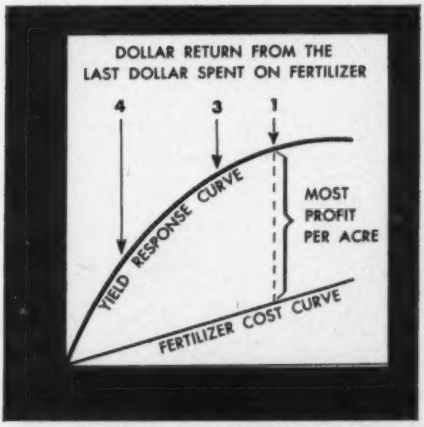


Figure 1—The response to added nutrients is *curvilinear*. Most profitable application rate is where the last dollar invested in fertilizer returns $1 in yield increase.

Dr. Stanley A. Barber, Professor of Agronomy at Purdue University, specializes in research on the nutrition of field crops. He earned his B.S. and M.S. degrees from the University of Saskatchewan in Canada, his Ph.D. from the University of Missouri. He was born in Saskatchewan, Canada.

THE PERCENTAGE YIELD CONCEPT—FIGURE 2

When such factors as *stand, variety,* and *moisture* are improved—causing a higher yield level—to get *maximum yield* you still need about the same level of lime, phosphorus, and potassium in the soil as you needed at lower yield levels.

You also need to use *more* plant food, of course, to maintain the level in the soil because higher yields remove larger amounts of nutrients.

This concept is illustrated in figure 2. It is called the percentage concept, because for each level of nutrient in the soil you get the same percentage of maximum yield.

Nitrogen does not follow the percentage concept. As maximum yields are increased, nitrogen requirement increases. This is probably because the crop removes almost all the nitrogen available in the soil.

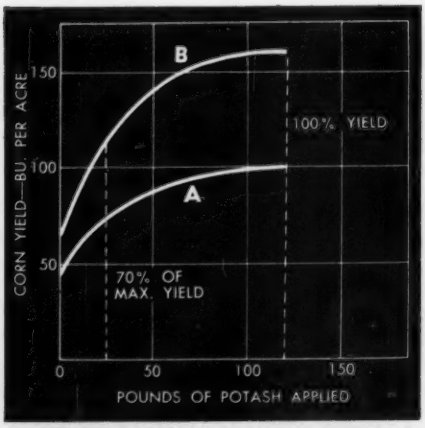


Figure 2—The percentage yield concept. When other factors allow a maximum yield of 160 bu. (curve B) instead of 100 bu. (curve A), it takes the same amount of potash to give 70% of the maximum yield in each case.

Since each nutrient acts differently, we need to consider them separately.

LIME

Lime for acid soils sets the stage for efficient use of the other nutrients.

Lime supplies calcium and magnesium. It counteracts the harmful effects of hydrogen and aluminum in acid soils. It improves soil structure.

Generally speaking, soils should be limed to a pH of 6.5 to 7.0. The amount needed depends on the pH, clay content, and organic content of the soil and the quality of the lime. Lime is added to change the whole soil environment into an optimum condition for plant growth.

In Ohio experiments, where manure and fertilizer were used on a rotation of corn, oats, wheat and hay, liming to a pH of 7.0 increased corn yields an average of 7 bu. over yields obtained at pH 5.4.

NITROGEN—FIGURE 3

Corn and other non-legume crops require large amounts of nitrogen.

How much is needed?

The need for nitrogen varies with the crop and its yield level.

In figure 3, the response curve of corn to nitrogen is used to determine the total needed.

A yield of 147 bu. per acre required 200 lbs. of N from fertilizer, along with 65 lbs. supplied by the soil.

The curve was extrapolated back to zero yield to get an estimate of the amount the soil supplied.

Requirement varies with yield level

The total nitrogen needs of a large number of experiments were plotted and determined in the way shown in figure 3.

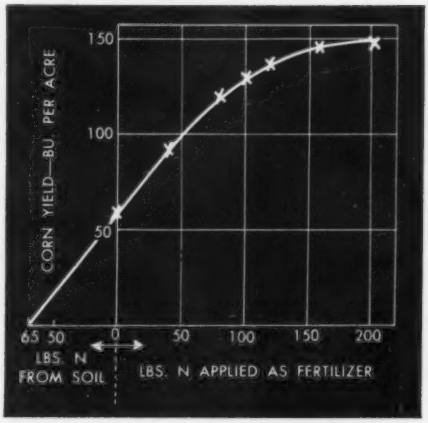


Figure 3—Here the 147 bu. corn yield required 65 lbs. of soil nitrogen and 200 lbs. of fertilizer nitrogen. (Data from Hunter and Yungen, Proc., Soil Sci. Soc. Amer. 19,214, 1955)

Where the top yield was 100 bu., the total nitrogen (soil + fertilizer) required was about 180 lbs. of nitrogen per acre and, as the yield level was increased, the requirement increased from about 1.8 to 2 lbs. of nitrogen for each bu. increase in maximum yield.

You should have 1.8 to 2 lbs. of nitrogen available in the soil for each bu. of yield you expect to obtain.

PHOSPHORUS—FIGURE 4

Phosphorus usually follows the percentage concept. A high soil level will usually be adequate for all yield potentials. Higher yields will require *more* phosphorus for *maintenance*.

Responses on many crops can be obtained up to the high soil test level.

How corn responded to phosphorus applications on a corn-soybean-wheat-hay rotation at the Purdue Agronomy Farm is shown in figure 4.

This Raub silt loam tested low in phosphorus. Phosphorus fertilizer was *initially broadcast* and after 4 years applied *in the row* for corn and wheat. The total phosphorus applied in 7 years is plotted against the average corn yield for this period.

For this 7-year period, it took an average of at least 100 lbs. of P_2O_5 per acre per year, regardless of placement, to keep phosphorus from limiting yield.

With the 300-lb. application, the soil test was increased to medium. With the 900-lb. application, it was increased to high.

Placing Phosphorus

Row application has been promoted widely. It stimulates early growth. But, tracer experiments conducted at many locations have shown conclusively that corn and many other plants use very little *row* phosphorus after the first month's growth.

Broadcast and plowed-under phosphorus and the soil's supply is used to supply the bulk of the crops' need for phosphorus.

To make sure phosphorus does not become a limiting factor to your yields, keep a high phosphate level in your soil. With higher rates of phosphorus becoming more common, phosphorus fixation is much less a problem in determining the most profitable application procedures.

When you use more than 40 lbs. P_2O_5 per acre for corn, you may find it more profitable to plow under most of the phosphorus and use a small amount in the row.

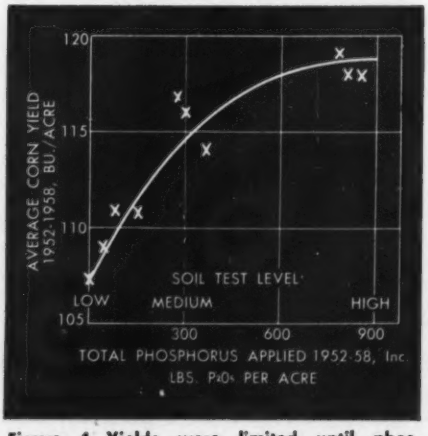


Figure 4—Yields were limited until phosphorus was built up to a high level in the soil. (Purdue Univ. data)

POTASSIUM—FIGURES 5, 6, 7

Corn and forage crops are heavy potassium users. A 150 bu. corn crop will absorb more than 150 lbs. of potassium from the soil.

How much available potassium do you need?

Potassium also tends to follow the percentage concept, shown in figure 2. To prevent potassium from limiting your yields, your soil should have an exchangeable level of 250 to 300 lbs. K_2O.

On some soils, this level can be obtained by broadcast applications.

On other soils, fixation may make it more profitable to apply only enough for one or two crops at a time.

Corn will respond to large applications of potassium. On a Red Bay fine sandy loam in Florida, Robertson and associates got corn yield increases by applying up to *90 lbs. of K_2O per acre annually*. The soil tested 112 lbs. initially.

In Indiana, the average response of corn to potassium in a corn-soybean-wheat-hay rotation is shown in figure 5. Both broadcast and row applications of potassium were used on a soil testing 110 lbs. of exchangeable K_2O per acre. For this seven-year period, it took more than 75 lbs. K_2O per acre per year to prevent potassium from limiting yield.

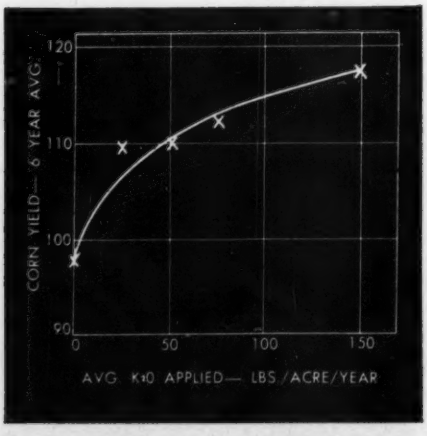


Figure 5—Large amounts of potassium were needed to obtain top corn yields in a corn-soybean-wheat-hay rotation. (Barber, Agronomy Journal 51, 97. 1959)

In this experiment, soil levels of *110, 150,* and *300* lbs. of exchangeable K_2O per acre were established and maintained.

Since no broadcast applications were made at the *110-pound level* treatment, this soil level was maintained by release of nonexchangeable soil potassium.

At the *150-pound level,* the maintenance amount was less than the amount removed in the crop grown so that some soil potassium was released and used.

At the *300-pound level,* the maintenance application had to be as much or more than the amount removed to prevent any reduction in soil potassium.

From the results of 144 field experiments, Dumenil and associates at Iowa State have calculated the expected corn yield increases from applied potassium as influenced by soil test level. These are shown in figure 6.

They also obtained responses of 2 to 3 bu. of corn with 10 lbs. of K_2O per acre in the row on some soils that were high in exchangeable potassium.

Placing Potassium

Placement of potassium is not as critical as placement of phosphorus.

Indiana experiments, using 0 to 240 lbs. of K_2O per acre, have shown that corn can get potassium just as well broadcast or plowed under as it can when it is banded 2 inches from the seed.

In banding, remember to keep the fertilizer away from the seed to prevent salt injury, particularly in dry years.

How rainfall affects soil potassium availability

In very dry and very wet years, *soil*

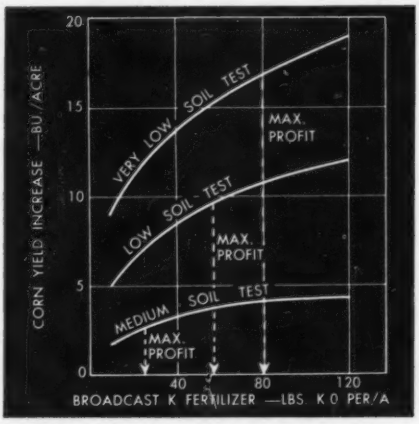


Figure 6—This chart shows the relation between soil test level and the response of corn to broadcast potassium. The rate for maximum profit is based on corn at $1 per bu. and K_2O at 6 cents per lb. (Iowa Farm Science 13,3, 1959)

potassium is less available, causing large responses to *potassium applications.* (See figure 7)

In such years, greater quantities of potassium are needed to keep it from limiting yields. Potassium deficiency may help drouth reduce your yields.

OTHER NUTRIENTS

Crops also require manganese, boron, molybdenum, sulfur, iron, zinc, copper and chlorine. Crops need these in small amounts which most soils can adequately supply. *However, a lack of any of these can also limit yields.*

On high phosphate or exposed subsoils, zinc deficiency has limited corn yields in some areas of Nebraska, Kentucky and Tennessee. Minor element needs are usually confined to only a few soils in an area. Research is now being conducted on these problems.

RESIDUAL EFFECTS

We don't usually consider residual (or carry-over benefits) when making fertilizer recommendations. If you consider residual benefits, the most sensible approach would seem to be the rotation fertilization approach, planning your fertilizer program for the next four or five years. Much larger applications may be more profitable, applying the bulk for the most responsive crops.

BALANCE OF NUTRIENTS

We have considered the nutrients separately. *But, to get maximum response to any one nutrient, the other nutrients should be present in the proper amounts.*

If they are not, you may get small yield increases as you increase the amount added and then yield depression at higher rates *because of imbalance of the nutrients.*

Remember: balance of nutrients does not refer to a balanced fertilizer but to a desirable balance when the soil and fertilizer are considered together.

To get this, you must have your soil tested and add the nutrients as needed to supplement the soil supply.

THE END

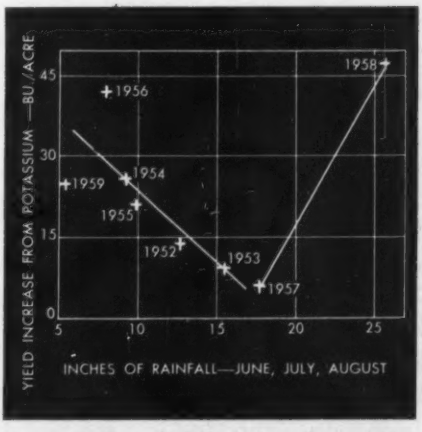


Figure 7—The rainfall during the growing season affects the availability of soil potassium (Purdue Univ. data)

Variety d

By

Glenn W. Burton

USDA, Tifton, Georgia

VARIETY is often the weakest link in the crop production chain. It may be the difference between profit and loss.

The extra cost of seed for the best variety will often give a far greater return per dollar invested than any other single item in your production.

Why, then, do thousands of farmers continue to plant inferior varieties and cut their profits? Apparently they don't know any better.

Many have been misinformed by an ignorant seedsman who told them one variety was as good as another. Some have believed the quasi-experts who preach, "Common will do as well as the new variety if you fertilize it."

It is hard to believe, but many farmers do not realize their Agricultural Experiment Stations spend thousands of dollars annually to find out which variety is best for them. They do not realize that a telephone call to their county agent or a post card to their Experiment Station will supply this information.

THE IMPORTANCE OF VARIETY

How important can variety be? In 1955, Morris, Fleming, and Kozelnicky, working at the College Experiment Station, Athens, Ga., completed a three-year study on the influence of fertilization and variety on corn yields on a Cecil sandy loam in the Piedmont of Georgia.

During this period, *Dixie 22*, the best hybrid, averaged 42.2 bushels per acre while *Hastings Prolific*, a popular open-pollinated variety, averaged 24.4 bushels per acre.

In 1955, a year with *normal moisture*, both varieties responded to increased fertilization, *but Dixie 22 consistently outyielded Hastings Prolific from 13 to 22 bushels per acre.* See figure 5.

In the *dry season* of 1953, *Hastings Prolific* yielded only 12.5 bushels per acre and failed to make any response to increased fertilization. *Dixie 22*, on

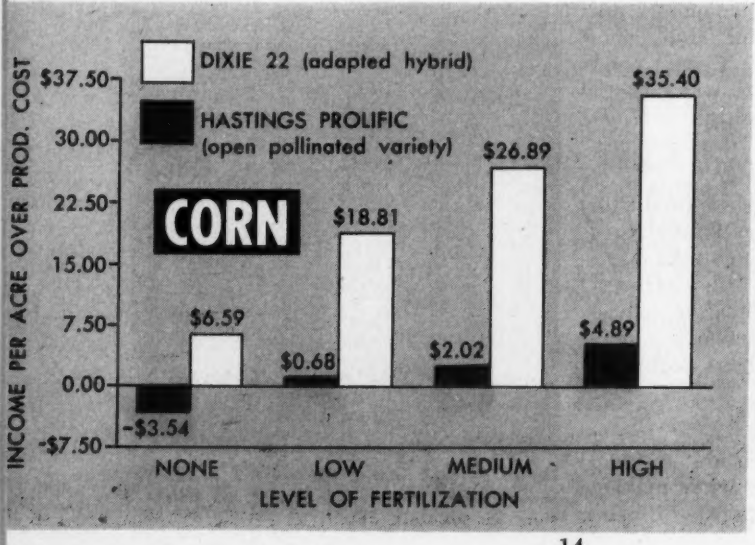


Figure 1 — A adap corn riet plus dequ fertili de is dif ence in co . (Fr average o resul Dixie 22 ould the farme only 5 per acre, whil bri $6.59 to $ .40 ore it pe acr dep ndin his tiliz on.

the other hand, yielded 2 to 3 times as much and responded nicely to increased amounts of fertilizer. (See figure 2).

CORN NO LONGER MULE FUEL

Corn, in Georgia, is no longer mule feed, "fuel" to power crop-growing operations. It is a *cash crop* and should be grown *only when it returns a profit above all costs.*

The costs of producing the corn in this study subtracted from the value of the crop sold at $1.25 per bushel give the net income per acre shown in figure 1.

The farmer growing Hastings Prolific without fertilizer would have lost money and his net income at any level

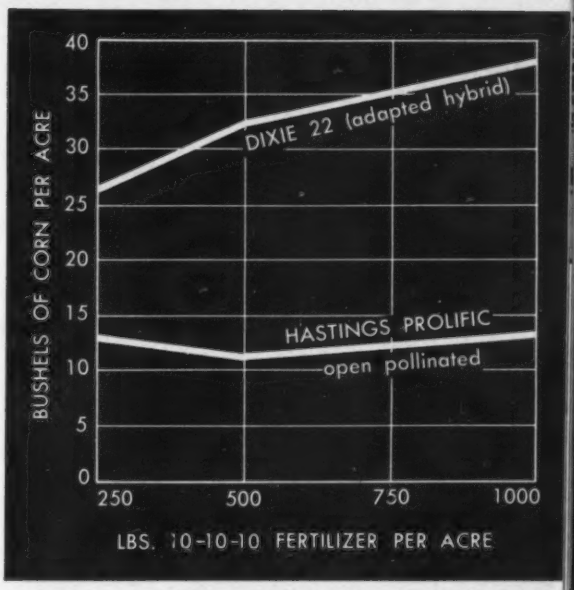


Figure 2—Response of Dixie 22 (adapted variety) and Hastings Prolific (open pollinated) corn to fertilization in a season of low rainfall (1953).

...Hybrid

DON'T LET IT BE THE WEAKEST LINK IN YOUR CROP PRODUCTION CHAIN

An important report showing how good varieties respond to plenty of fertilizer . . . producing profitable yields even in dry seasons . . . in contrast to inferior varieties.

of fertility would have been less than $5.00 per acre.

By paying 75 cents per acre more to plant the best hybrid, *Dixie 22*, he could have realized a net profit of $6.59 to $35.40 per acre depending on the amount of fertilizer he applied. Thus, *each dollar* invested in Dixie 22 hybrid seed could have *returned $13.00 to $40.00 to his pocket* if he had been smart enough to plant the best hybrid instead of his "old open-pollinated stand-by."

IMPORTANT ON PASTURES & FORAGE CROPS

Variety may be even more important when one looks at pastures and forage crops. For years one could find

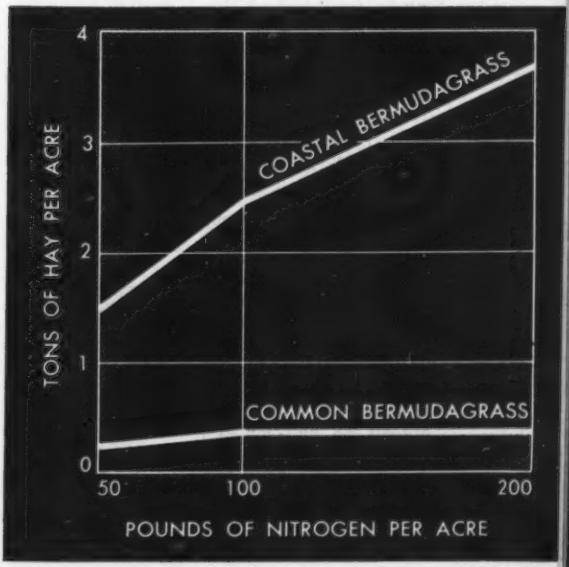


Figure 3—Response of Coastal- and common Bermudagrass to nitrogen in a season of low rainfall (1954).

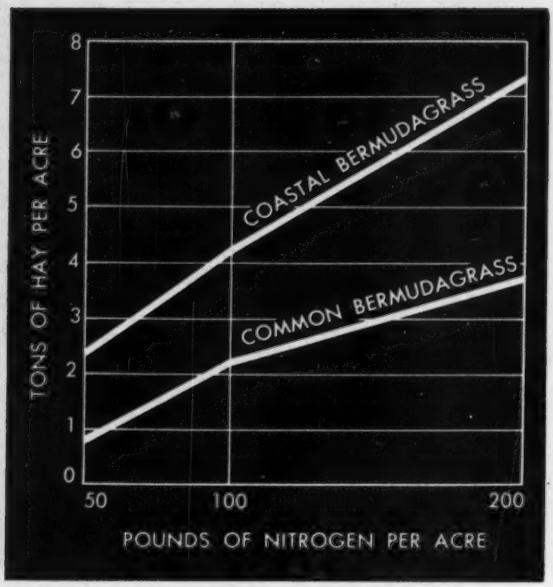


Figure 4—Response of Coastal- and common Bermudagrass to nitrogen in a season of high rainfall (1953).

in every group of Georgia farmers those who would say, "If you fertilize common Bermuda like they fertilize Coastal, common will do just as well."

Experiment Stations across the South and many farmers have answered these doubters with results such as those shown in figures 3 and 4. In the very favorable growing season of 1953, both common and Coastal Bermuda growing at the Georgia Coastal Plain Experiment Station at Tifton, Georgia, responded to increased amounts of nitrogen, *but Coastal produced from 1½ to 3½ tons more per acre than common Bermuda.*

At $25.00 per ton the farmer with Coastal Bermuda would have received *$37.50 to $87.50 more per acre* than his neighbor applying similar amounts of fertilizer.

In the very dry season of 1954, common Bermuda made practically no response to fertilizer and produced only ½ ton of hay per acre. Coastal Bermuda, on the other hand, responded to increased fertilization, yielded up to 3¾ tons per acre, and produced *over 6 times as much as common.*

More than one cattleman using Coastal Bermuda reported that without this variety they would have been forced to sell their cattle in 1954. Not only has Coastal Bermuda been more productive, more responsive to fertilizer and more dependable, but it has recovered from 2 to 5 times as much of the nitrogen, phosphorus, and potassium applied as the common type.

Dr. Glenn W. Burton is Principal Geneticist on forage crops and diseases at Georgia's Coastal Plain Experiment Station. Best known of the new grasses he and his associates have developed is the Coastal Bermuda variety for which he received the John Scott Award in 1957.

BEST HYBRIDS RESPOND TO PLENTY OF FERTILIZER IN DRY SEASON

The opinion still prevails that in dry years heavily fertilized crops will burn up and actually yield less than those receiving little if any plant food. This may be true if old inferior varieties are planted. *It is not true if the best varieties and hybrids are used.* Proof of this statement may be found in figures 2 and 3.

Small grain yields are frequently limited by the inability of the straw to hold the grain off the ground until it can be harvested. To help solve this problem in the Pacific Northwest, O. A. Vogel and his associates are breeding semi-dwarf wheats, much shorter than old varieties.

One experimental hybrid, only 29 inches tall, outyielded the 42-inch checks by 23% in four locations over a 2 year period. In the most favorable site, it yielded 106.0 bushels per acre. Similar changes in other small grains should permit higher yields and greater profits for the growers.

RESISTANT VARIETIES CAN CUT GROWING COSTS

American farmers spend millions of dollars annually for chemicals to control insects, diseases, and weeds. These expenditures must be borne by the crop to which they are applied. Substituting resistant varieties, where they are available, for the susceptible ones can often greatly reduce the cost of growing the crop.

The rapid spread of the spotted alfalfa aphid in 1954 and 1955 threatened much of the alfalfa in the United States because costly chemical sprays appeared to be the only control for this insect. The discovery that the Lahontan variety was resistant led to its rapid increase and use at a saving of thousands of dollars to alfalfa growers.

The use of the disease and weed resistant Tifgreen Bermuda grass on golf greens can materially reduce the club's expenditures for fungicides and herbicides.

POTASH HELPS RESISTANT VARIETIES FIGHT DISEASES

The comparatively low per acre value of many field crops makes the cost of disease control with fungicides prohibitive. Here the development and use of resistant varieties offer the only practical solution to the problem.

Fertilization programs that permit a deficiency of one or more elements, *particularly potassium,* may, however, increase the amount of disease on resistant varieties. Otto and Everett observed that the resistant corn hybrid Ohio 51A X Iowa B8 developed more stalk rot when nitrogen alone was applied than when nitrogen and potassium were applied together.

Nitrogen alone or in combination with potassium had no effect on the amount of stalk rot in the susceptible hybrids.

Many grasses that normally are highly resistant to foliage diseases develop leaf spots and appear to be injured by diseases when suffering from potassium deficiency.

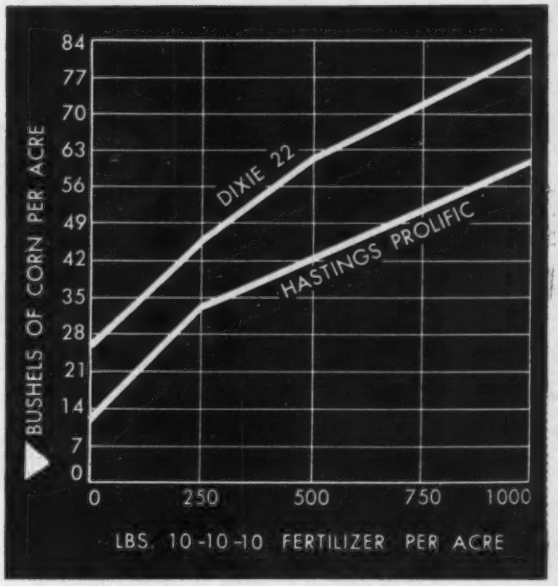


Figure 5—Response of Dixie 22 and Hastings Prolific corn to fertilization in season of normal rainfall (1955).

QUALITY OFTEN DEMANDS CERTAIN VARIETIES

Varieties differ in quality as well as yield. Often the exacting demands of the consumer can only be met with certain varieties. In the hard red winter wheat country, for example, the market pays a premium for high-gluten varieties and docks or refuses to buy soft low-gluten wheats.

To satisfy a demand for a specific type of fiber, cotton farmers within a large community often voluntarily grow one variety. To insure that only the strong fibered Acala 442 cotton variety will be grown in the San Joaquin Valley of California, farmers in the valley have caused a law to be passed making it illegal to grow any other variety. Violators of the law must destroy their crop. Thus, where quality is important, choice of the wrong variety may result in a com-

plete loss of the entire enterprise.

As the formulation of livestock feeds becomes more exacting, greater attention will be given to the chemical composition of the raw products that go into them. Anticipating this development, plant breeders and agronomists are searching for methods of increasing the oil, protein, and other constituents in corn and other feeds.

"POOR" SOILS NO LONGER CONCERN OF PLANT BREEDERS

Breeding varieties adapted to poor soils was an objective for many plant breeders a quarter of a century ago. Today this objective is rarely, if ever, found. A number of factors are responsible for this change:

1 Research has shown that most of the so-called poor soils can be made fertile by applying commercial fertilizers.

2 Economic studies have proved that low unit cost of product is almost invariably associated with high yields obtainable only on fertile soils. This has led to wide use of commercial fertilizers even on the rich prairie soils of the corn belt. Thus, plant breeders must now breed varieties capable of giving maximum yields on fertile soils.

3 Since fertility as adjusted by the application of fertilizer can vary greatly, and since many farmers fail to use the optimum amount of fertilizer on many of their crops, it is often necessary to test new varieties at more than one fertility level. Often top varieties at one fertility level will be tops at another. This, however, is not always true.

Certainly, today's plant breeder dare not ignore soil fertility as he strives to develop improved varieties that will not limit tomorrow's production.

THE END

For Reliable Soil Testing Apparatus there is no substitute for LaMOTTE

LaMotte Soil Testing Service is the direct result of 30 years of extensive cooperative research. As a result, all LaMotte methods are approved procedures, field tested and checked for accuracy in actual plant studies. These methods are flexible and are capable of application to all types of soil, with proper interpretation to compensate for any special local soil conditions.

Time-Proven LaMotte Soil Testing Apparatus is available in single units or in combination sets for the following tests:

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Nitrite Nitrogen	
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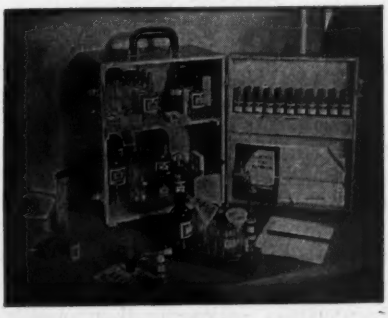
Chlorides	Aluminum
Sulfates	Replaceable Calcium

Tests for Organic Matter and Nutrient Solutions (hydroculture) furnished only as separate units.



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INSECTS...

European corn borer at work in sweet corn (USDA Photo)

By J. W. Apple
University of Wisconsin

ALL FIELD crops are attacked by at least a few insects that chew away their roots, leaves, or stems or suck out their fluids.

Sometimes insects destroy almost all of a crop in a certain field or area. But the usual problem is low-order damage in every field year after year.

In recent years, this "minor" injury has been recognized as a significant problem which should be controlled.

CORN IS ATTACKED BY MORE INSECTS THAN OTHER FIELD CROPS

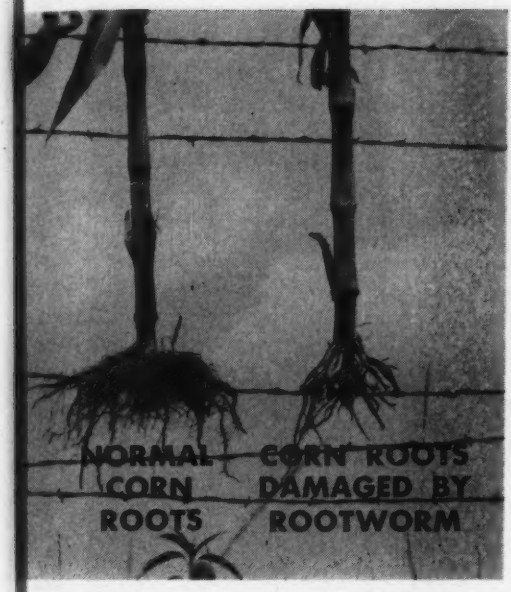
Corn gets hit by more species of insects than any other field crop. Damage usually begins not long after seed is placed in the ground. In fact, the sequence of attacks can run something like this:

1 Wireworms, seed maggots and seed beetles, on the average, remove about 3 per cent of the stand before the plants are one inch high.

2 Continued attacks by wireworms—plus damage from cutworms, billbugs, webworms, and white grubs eliminate another 3 to 4 per cent of the plants during the seedling stage and weaken many surviving plants.

3 Rootworms (three species) appear later to feed at the base of the plant and cause numerous unproductive and/or lodged (goosenecked) plants.

Observations made in Wisconsin during 1959 show how insect damage reduces the sugar of corn plants. Four-inch corn seedlings cut off by cutworms produced plants with an average ear weight of 0.7 pound (field weight), while undamaged seedlings produced 0.91-pound ears. Ears from plants severed at ground level when 6 inches high averaged 0.43 pound.



. . . Are They Limiting Your Crop Production?

And plants eight or more inches high at time of damage had no regrowth because the growing point was destroyed.

You can get maximum protection from all soil insects attacking corn by using broadcast applications of certain insecticides. (See treatment table.) Many growers like row treatment, which can be about as effective as broadcast applications. Post-planting treatments have little effect on wireworms, maggots, grubs, and rootworms but can be used to control cutworms, true armyworms, billbugs, and webworms. (See treatment table.)

Facing the Corn Borer

4 Midseason and maturing corn plants are attacked largely by the European corn borer, leaf aphid, chinch bug, grasshoppers, fall armyworm, and earworm. During a five-year period 1954-58, the corn borer caused a 1.5 per cent average crop loss over the entire infested area and a 20 per cent average loss in the most heavily infested areas of the corn belt.

This insect is surprisingly uniform from field to field. Only in the most heavily infested regions is it economical to apply insecticidal control. When a field has leaf feeding on 75 per cent or more of the plants during late June and early July, treatment is justified. The USDA has granted labels for various insecticides at specified rates per acre. (See treatment table).

Facing the Corn Leaf Aphid

5 The corn leaf aphid has attracted much attention during recent

TREATMENT FOR CERTAIN INSECTS ON CORN, SMALL GRAIN, ALFALFA

CORN

Soil Treatment for Insect Complex

Broadcast 1.5 lbs. of aldrin immediately before final discing (Raise rate to 5 lbs. per acre in muck soil).

Row treatment—apply 1 lb. aldrin per acre (2 lbs. in muck soil) by placing it in soil above or to side of seed, such as, fertilizer-insecticide mixture through split-boot attachment (not deep placed) or by special equipment mounted on planter to apply spray or granules into soil above seed. Corn rootworms require only half this rate.

Post-Planting Treatment for Cutworms, True Armyworms, Billbugs, Webworms

Apply 2 lbs. toxaphene per acre. (0.5 lb. of dieldrin per acre on black and glassy cutworms that remain and feed underground.)

Confine sprays of toxaphene or dieldrin to 12-inch band over the row so plants and adjacent soil are well covered.

Corn Borer

Per acre rates for ear corn plantings; 1 to 2 lbs. DDT used as dust, spray or granule.

Or

0.2 to 0.25 lb. endrin—used as spray or granule.

Or

2 lbs. toxaphene—used only as granule.

Corn Leaf Aphid

If ten percent or more of your plants have over 500 aphids per plant before pollen shedding, apply 1 lb. of malathion dust or spray per acre by high clearance ground equipment or airplane.

SMALL GRAIN

Greenbug

Apply 0.25 lb. of methyl parathion or regular parathion per acre or 1 lb. of malathion per acre.

Armyworm

Apply 2 lbs. of toxaphene per acre.

ALFALFA

Spotted Alfalfa Aphid

For new seed treatment in infested areas:

Use a charcoal base dust of either disyston or thimet at 1.5 lbs. actual chemical per 100 lbs. of seed.

For established plantings:

Spray 0.75 lb. of malathion per acre—

Or

Spray 0.25 lb. parathion per acre—

Or

Spray 0.25 lb. demeton per acre.

Alfalfa Weevil

Apply 1 lb. of methoxychlor per acre on first growth for adult control and a second application if necessary after first cutting.

Pea Aphid

Apply 0.75 lb. of malathion per acre alone or in combination with methoxychlor used for other insects.

Potato Leafhopper

Apply 0.5 lb. of methoxychlor or 0.75 lb. of malathion per acre after second growth has reached 6-8 inches.

years because of high populations on corn, sorghum, and barley.

On corn, the aphids appear in the plant whorl before tassel emergence, sometimes increasing very rapidly, literally covering the emerging tassel. Later the aphids move to the foliage and can kill one or more leaves during early ear development. This leaf damage can affect ear growth but usually is small because aphids often succumb to diseases, predators, and parasites as they move from the drying tassel.

Many entomologists have noted that scattered plants with heavy tassel infestations produce barren ears. But no one has determined whether such plants have a physiological abnormality that leads to barrenness and this same condition attracts a disproportionate number of migrating aphids or else results in their more rapid development.

We do know this. Too often farmers apply chemical control about the time aphid decline begins, receiving no benefits from the treatment.

Facing Miscellaneous Corn Insects

Grasshoppers on a planting to be used for ear corn can be controlled with the following insecticides at the indicated rates per acre: aldrin ¼ lb., or toxaphene 2 lbs.

Fall armyworm and earworms in the plant whorl can be eliminated by the use of 2 lbs. of DDT per acre.

Corn can be protected from migrating chinch bugs by spraying a four rod strip on the susceptible side of the field with dieldrin at ½ lb. per acre. Half of this sprayed strip should be in the adjoining small grain stubble and one half in the corn.

FIGHTING INSECTS ON SMALL GRAINS

In most sections of the nation, insect damage causes little concern to small grain producers.

The Greenbug

The greenbug is probably the most important insect because it attacks winter wheat in the South-central states. Greatest losses from this aphid come when cool springs follow a mild winter. Predators and parasites are not active below 60°F temperatures.

This aphid, on the other hand, can produce offspring and feed down to 40°F temperatures. Sometimes it is abundant on oats in the North-central states, as in 1959. This attack was doubly serious last summer because many of the aphid migrants from the South brought yellow dwarf (red-leaf) virus into spring-planted oats. In spite of satisfactory control with insecticides, the oats developed symptoms of the virus disease from early inoculation, causing very disappointing yields. This situation was unusual. It may not occur again for many years. (See treatment table for greenbug control).

Armyworms

Armyworms, which can be found in most small grain fields each year, are a consistent limiting factor only in the Gulf states where they winter. Twice during the past decade (1952 and 1954) oats and corn in the North-central states were attacked by armyworms. These infestations developed unnoticed until the worms were large enough to do extensive damage.

This condition should not repeat itself because major moth migrations

—CONTINUED ON PAGE 26

Dr. J. W. Apple, Professor of Entomology at the University of Wisconsin, is a widely known specialist in field crop insects. He is Chairman of North Central Branch of the Entomological Society of America. Native of Ann Arbor, Michigan, he earned his B.S. at Ohio State, M.S. at Iowa State, and Ph.D. at Illinois.

COUNT DOWN! . . .

THE FERTILIZER you plan to use is without question some of the best chemical plant food the world has ever had. When used under conditions that give it a chance to work, fertilizer will always make you a good profit from top yields.

Many farmers use fertilizer and obtain only state average yields (60 bu. per acre or less). Does this mean that the fertilizer they used was not good? Not necessarily. It probably means there were a lot of other factors operating in their corn fields that put the brakes on the good fertilizer they used.

It takes more than just fuel to make a good rocket. Likewise it takes more than fertilizer alone to make a good corn crop. In each case both are necessary but a lot of other things are necessary, too. When something besides fertility is holding corn yields down, additional fertilizer merely adds to their costs and further reduces profits.

When you "Shoot For The Moon In Corn Profits", it is well to see if all the other necessary parts to make a good corn crop are present and working. The following check list will help you gauge how effective your fertilizer can work in your annual shot for a high corn yield.

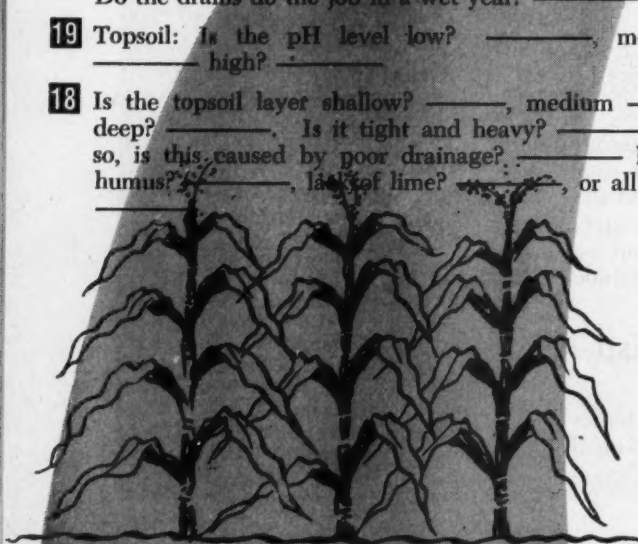
FACTORS AFFECTING CORN YIELDS

Field and Soil Factors—

20 Drainage: Any tile system does all right in a dry year. Do the drains do the job in a wet year? ————

19 Topsoil: Is the pH level low? ————, medium? ———— high? ————

18 Is the topsoil layer shallow? ————, medium ————, deep? ————. Is it tight and heavy? ————. If so, is this caused by poor drainage? ———— lack of humus? ————, lack of lime? ————, or all three? ————



17 Subsoil: Is the pH l… high? ————. C… a… readily? ————. …do… gravel? ————, ro…

16 Are there hardpans o… es

15 Has the soil been te… n t… (lime), P + K? ——

Management Factors—

14 Do you plow when t… t…

13 Do you plow deep e… pare a good seed be…

12 Do you follow a rot… d… ————.

11 Do you use a split h… of … so, is it in good repa… uste…

10 Better yet: do you u… ndi… old planter? ———— do… planter with the s… ng…

9 When planting is y… sp… planter was designed… e? —

8 Are you using varie… to … ————.

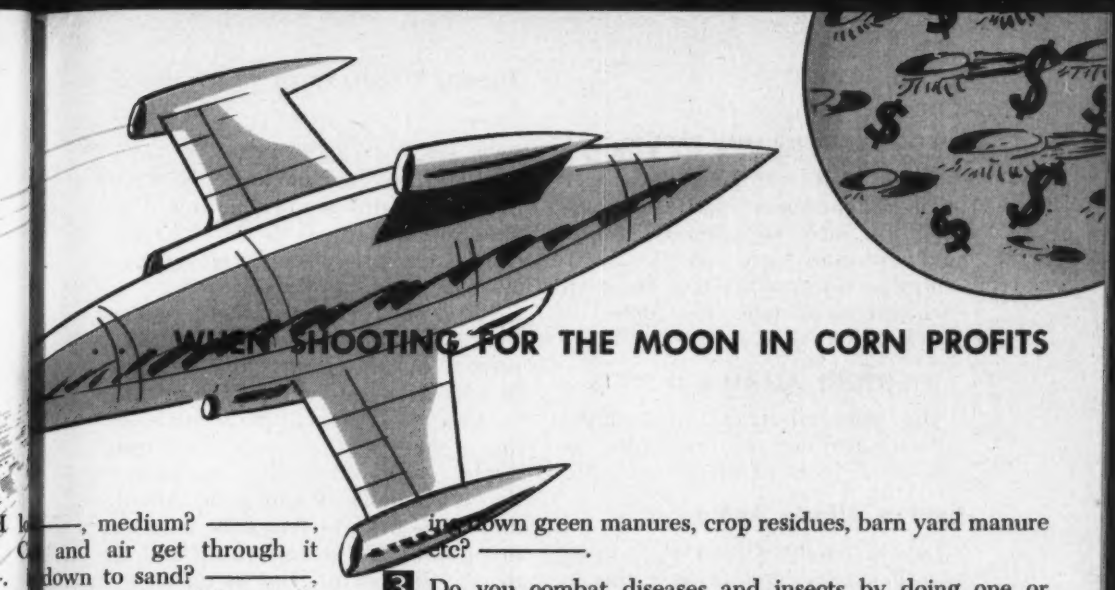
7 Do you plant the ma… pula… ply and fertility level… ort?

6 In cultivating do yo… yo… Do you tear out corn… n cu… ————.

5 Do you control weed… er h… ing? ————.

4 Where the soil is d… yo… Do you build up wa… cap…

BY JIM MORRO… PU…



WHEN SHOOTING FOR THE MOON IN CORN PROFITS

—, medium? ————,
and air get through it
down to sand? ————,
—, water table? ————.
es in the field? ————.
the past 3 years for pH

too wet? ————.
—— and do you pre-
—.
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of planter? ————. If
sted properly? ————.
nding attachments on the
do you have a modern
ng mechanism built in?
speed that at which the
?————.
to your soil and locality?

pulation the moisture sup-
ort? ————.
young plants? ————.
cultivating larger plants?

er by cultivation or spray-

you irrigate? ————.
capacity of soil by plow-

in down green manures, crop residues, barn yard manure etc? ————.

3 Do you combat diseases and insects by doing one or more of the following: Spraying? ————, using better rotations? ————, maintaining suitable levels of lime, P, and K in the soil? ————, using treated seed? ————.

2 Do you harvest and store the crop efficiently? ————.

1 Do you habitually get field operations done (weather permitting) when they should be done? ————.

(If answers indicate chances are favorable for a SUCCESSFUL SHOT, everything is now set for maximum results and profits from good fuel.)

0 Blast off with a Full Charge of Needed Fertilizer.

When one or more of the factors listed are holding yields down, the net profits from the use of larger amounts of fertilizer tend to become less. You should fertilize only up to the yields that these factors will permit. As you improve your position with reference to these factors, you can use higher and higher rates of fertilizer profitably. Soil Tests from time to time will help you check your fertility position and progress.

However, if you know the field is tied down with a lot of conditions or practices which in themselves will depress yields, you are costing yourself money when you apply large amounts of costly fertilizer simply as a Cure-All.

Fertilizing done in the right association with all the factors listed is one of the most profitable cropping practices. Done in the wrong association part of it can be an item of dead expense.

If the correction of any of these conditions requires a greater amount of technical knowledge than you may have, your Country Agent, your Agricultural College Extension Specialist, your S.C.S. Technician and others are anxious to consult with you and help you if you will ask them.

THE END

INSECTS—CONTINUED FROM PAGE 23

from the South can now be detected by black light insect traps. This equipment can alert areas receiving high moth invasions early enough to start control on worms while they are small. (See treatment table for control of armyworms.)

FIGHTING ALFALFA INSECTS

Our principal forage crop, alfalfa, suffers major damage from insect attack in all parts of the country.

Spotted Alfalfa Aphid

Losses from the spotted alfalfa aphid have fluctuated greatly since this insect first appeared in New Mexico in 1954. In 1956, when it cost alfalfa farmers $40,000,000, the spotted aphid moved north into Wisconsin. But since that time it has been found only in the southern half of the country and on the Pacific Coast.

The spotted aphid cannot survive temperatures below 10°F. During years favorable to multiplication it can destroy an alfalfa crop, especially new seedings. The greatest hope for future protection against it lies in the development of resistant varieties. (See treatment table for new-seed treatment in infested areas and for control on established plantings).

Alfalfa Weevil

Prior to the spotted aphid, the most serious alfalfa pest in this country was the alfalfa weevil. It was first noted in Utah in 1904 and since then has spread to 13 neighboring states.

In 1951, this weevil showed up in Maryland and during the eight intervening years moved into nine Mid-Atlantic states. It was found in central Kentucky during the summer of 1959. Because it can travel so well (20 miles each year), we may look for it to infest most alfalfa producing areas.

Both adult weevils and larvae feed on alfalfa foliage. To control it, use insecticides for overwintering adults during early spring and if necessary repeat shortly after the first cutting. Until recent months, 0.25 lb. of heptachlor per acre has been the most popular insecticide for alfalfa weevil.

But it has been found that a heptachlor break-down product (eposcide) persists on the plants for a longer period, so the Food and Drug Administration has asked for a reevaluation of this insecticide on forage crops. Before using heptachlor on forage during 1960, check with your agricultural authorities to determine whether this chemical is recommended and, if so, the number of days to allow between treatment and harvest, to assure no residual of either heptachlor or its eposcide.

An alternate but expensive insecticide is methoxychlor, applied at 1 lb. per acre. (See treatment table).

Other Insects on Alfalfa

Pea aphids frequently occur in great numbers on both first and second-crop alfalfa. Heptachlor and methoxychlor are no good on this pest. You should use malathion. (See treatment table).

Potato leafhoppers survive the winter only in the Gulf states. But each spring (May), air currents transport adults into the Northern states where their offspring produce yellowing and stunting in second-growth alfalfa. Although losses are not so obvious as those from spotted aphid and weevil, several hundred pounds of hay per acre can be lost in a normal year and much more during dry seasons. (See treatment table for control).

Grasshoppers are commonly destructive mid and late season. You can eliminate them by using 0.75 to 1 lb. malathion per acre.

Take special care when using insecticides on alfalfa, or any other crop. Follow label directions to avoid harvesting too soon or after application. And do not apply insect poisons during alfalfa bloom because of danger to bees. **THE END**

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The AMERICAN GRASSLAND COUNCIL

AN OPPORTUNITY WORTH TAKING

Better Crops magazine recently received a highly interesting kit of materials describing the current work of the American Grassland Council, which was formerly the Joint Committee on Grassland Farming.

A brief look at its history, plans, and objectives, as well as its new quarterly publication, *Grassland Progress*, should convince anyone that there are many advantages to being a member of the American Grassland Council. Among them are:

1—*A quarterly publication.* *Grassland Progress* which capsules important happenings in grassland agriculture—meeting notices, new books, research reports, important conferences, reports of successful applications of research developments. It's a natural for all forage workers to keep in touch with research in their chosen field.

2—*Annual Proceedings.* These list the important topics covered by lectures at Council meetings along with the authors. The past proceedings covered 13 different subjects, all highly important to forage farmers, scientists, and industrialists. Two examples: "The Importance of Grasslands in Our National Life" by H. B. Sprague of Penn State and "New Frontiers in Range Management" by Merton Love of California.

3—*Newest Developments in Grassland Research and Its Applications.* A non-profit organization dedicated to bringing together what science and technology are doing to improve grassland farming and how a wide range of businesses and industries are applying these findings. Its present officers and members represent many areas of grassland agriculture—research, education, industry, and business. And the 21 cooperating member organizations include important scientific societies, trade associations, and industrial corporations. All areas of membership are encouraged to contribute information on grassland farming to the membership.

4—*A Part of An Important Nation-wide Movement.* As an individual member, you are entitled to full membership privileges, to elect Board Members, to attend annual meetings held in different parts of the nation, to receive notices of special conferences and meetings, and to secure the latest news on other important grassland activities in which you may wish to participate. You will be a part of broad action programs to focus public attention on the importance of grasslands to this country.

There is not room to discuss all the Council's work and its future here. For free and interesting information on the Council and how to join, write Zur Craine, Executive-Secretary, American Grassland Council, Box 30, Norwich, New York.

WATER

. . . A VITAL FACTOR IN YOUR CROP PRODUCTION

By Wynne Thorne
Utah State University

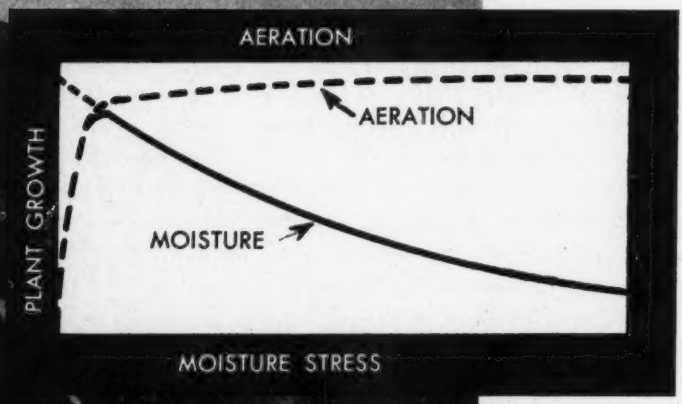
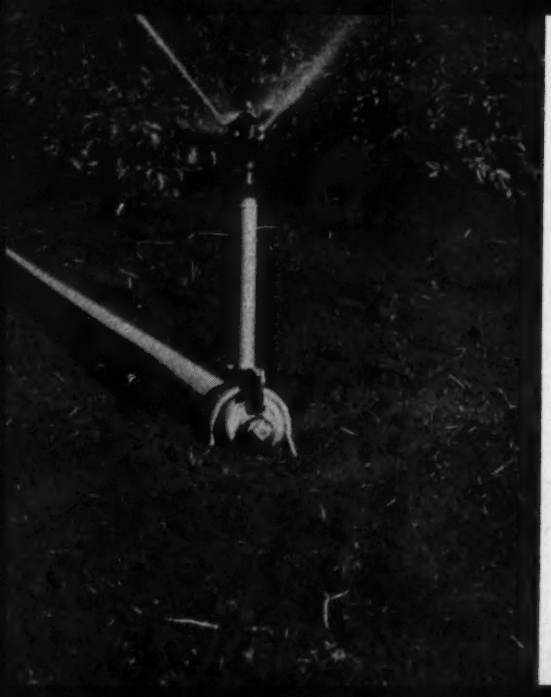


Figure 1—Plant growth increases as moisture stress decreases, until water excludes air from the soil and the decline in aeration becomes critical.



UNDER average conditions a crop producing *five tons of dry matter* per acre requires *four million pounds of water.* This exceeds the total nitrogen demand by 20,000 times and the phosphorus demand by 200,000 times.

To supply water for 65 acres of such a crop would require a 10-ton truck load of water delivered once each minute, 24 hours a day, 7 days a week, over a 3-month period.

When such staggering quantities are involved, the surprising fact is not that water is frequently deficient, but that enough water can be supplied to large areas of land to produce abun-

WESTERN EXPERT SHOWS . . .

How adequate plant food can help you get the most out of your water supply

. . . whether it's 1.69 more bushels of corn per inch of water consumed.

. . . or 33% less water used per ton of alfalfa hay.

. . . or nearly 50% less water to produce a pound of sudangrass.

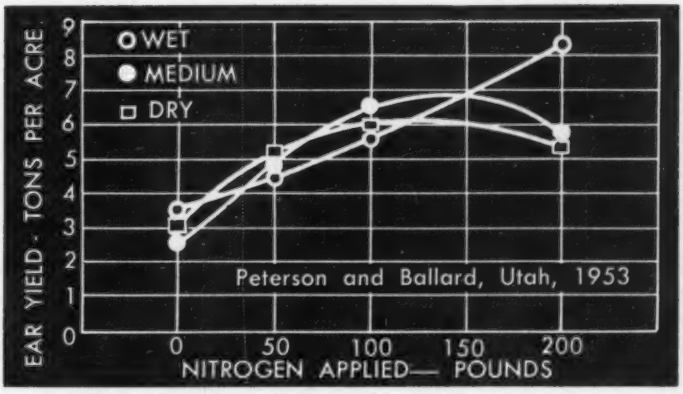


Figure 2—Sweet corn yields in this experiment were increased to a maximum by combining plenty of moisture and liberal applications of plant food.

dant yields. Von Helmont was near the truth (quantitatively) when he concluded in 1620 that water is the substance of plant life.

WHY MOISTURE SUPPLY MUST BE REPLENISHED

A five-ton yield requiring four million pounds of water during the growing season would use up three times the total available water a soil of medium texture can hold in a three-foot depth. Moisture supply must be replenished many times during the growing season of most crops, mainly for two reasons:

1 Few crops can utilize water uniformly to a depth of 3 feet.

2 Growth usually decreases progressively as plants are forced to use the second half of the soil water classed as "available."

The frequency with which water needs to be replenished varies with the soil, the crop, and such climatic variables as temperature, humidity, and air movement.

An ideal farm soil must take in water readily and hold a large quantity available to plants, yet permit rapid drainage of excessive water. *Too much water can fill the larger*

soil pores and exclude air needed for normal root activity. These water relationship qualities of soil cannot be changed too much without great cost. But chemical conditions such as pH and content of available plant nutrients can often be readily improved.

DON'T LET WATER SUPPLY CUT OFF YOUR SOIL'S AIR SUPPLY

Successful vegetative growth depends greatly on the ease with which plants can get water from the soil. S. A. Taylor in Utah (1959) measured the tension of water throughout the root zone for a number of crops over an 8-year period. He found that plant growth increases as moisture stress decreases until water excludes air from the soil and aeration decrease becomes critical—as shown in Figure 1.

The maximum yield obtained under these conditions was near or slightly below field moisture capacity (0.1 to 0.3 atmospheres stress).

The principal points on the curves of figure 1 vary somewhat for different soil and plant situations but the relationships are general. As soil moisture is increased, plants obtain needed water supplies more easily and are able to make more growth. But, also, as water is added to the soil, the soil pores can become filled with water until air is excluded. Then rapid decline in growth is caused by lack of oxygen for root respiration and not by excess water as such.

In some *fine-textured soils* with poor soil structure, air may become a limiting factor well below field capacity. Other *well-drained soils* seem to be adequately aerated even when irrigated almost daily.

The influence of water on plant growth differs between humid and arid regions. Water added by irrigation always contains some salts that reduce its effectiveness on plants. Crops in humid areas actually require less water because their transpiration losses are less than crops in arid areas. Water supplied by irrigation is usually controlled by the farmer who can control moisture deficiencies more closely than the farmer depending on rainfall.

However, available water supply in the root zone affects plant growth generally about the same in both humid and arid regions. The differences come when adjustments are made to secure maximum benefits through available water supplies.

In humid regions, the big question is whether periods of moisture deficiency occur frequently enough and reduce crop yields sufficiently to justify the labor and expense of installing irrigation systems. The answer depends on markets and crops grown, as well as possible yield increases from irrigation.

HOW DIFFERENT CROPS REMOVE MOISTURE FROM DIFFERENT SOIL DEPTHS

In the studies of S. A. Taylor (1959) of Utah, four irrigation regimes were governed by irrigating at different tensions of soil moisture in the root zones of the crops. The soil was Millville loam, well aerated and relatively uniform in texture to 10 feet or more deep.

Four crops—alfalfa, potatoes, sugar beets, and *peas*—responded to moisture as shown in the general trend curves of figure 1. But, these crops varied in the depth from which they removed moisture. For example:

1. *Alfalfa* in its second year removed water to a depth of *8 feet.*

2. *Sugar beets* extracted water to a depth of *4 feet.*

3. *Russett Burbank potatoes* removed water to *3 feet.* but *Red Bliss potatoes* used it to *only 30 inches.*

4. *Canning peas* to *24 inches.*

The deep-rooted crops, of course, can go longer between water additions than the shallow-rooted ones.

SOME EFFECTS OF MOISTURE DEFICIENCY

Since soil moisture fluctuates widely, most crops under field conditions suffer moisture stress during at least part of the growing season.

Wilting is the first pronounced symptom of moisture deficiency. This usually occurs when plants have lost *20 to 30 per cent* of their water content.

Some information is available on the effects of short-period moisture deficiency on plant-growth and on total seasonal yield. Wadleigh and Gauch (1948) observed (1) that elongation of cotton leaves slowed up and ceased as soil moisture stress approached the wilting point, (2) that growth resumed rapidly after irrigation.

Others have observed that photosynthesis slows up as leaves wilt or lose water and become less turgid.

Studying the effects of temporary water deficiencies on plants, Owen and Associates in England (1956 and 1958) found that after prolonged drouth small amounts of rainfall caused large increases in leaf growth and photosynthesis so that temporarily these plants grew faster than those that had never suffered moisture stress. But, the total growth of the plants subjected to prolonged moisture stress was much less than the well watered plants.

When the most favorable soil moisture conditions are maintained, other good management practices start to pay off and yields increase. More plants can be grown per acre with plenty of moisture and *fertilizers become more effective.*

HOW MOISTURE AND FERTILIZER WORK TOGETHER FOR TOP YIELDS

The interaction of soil moisture and available nitrogen supply is often striking in crop yields.

Peterson and Ballard (1953) irrigated sweet corn at three frequencies

Dr. Wynne Thorne is Director of the Utah Agricultural Experiment Station. He has been President of the Soil Science Society of America, as well as Professor of Soils and Head of Agronomy at Utah State University. A well-known authority on irrigation, Dr. Thorne has conducted research and written exclusively on problems associated with irrigation agriculture.

with the *least frequent irrigation being about the average practice* of the area (Figure 2). *Without adding fertilizer,* more frequent irrigation than the standard practice *did not increase the yield.* When 200 pounds of nitrogen was applied per acre, the sweet corn yield increased to 8.2 tons per acre with the most frequent irrigations (7 per season).

In the same experiment, the 200 pounds of nitrogen used with average irrigation practices (2 irrigations) increased yields 2.6 tons over average irrigation without fertilizer. And 200 pounds nitrogen used with frequent irrigations increased yields 5 tons over frequent irrigations without fertilizer.

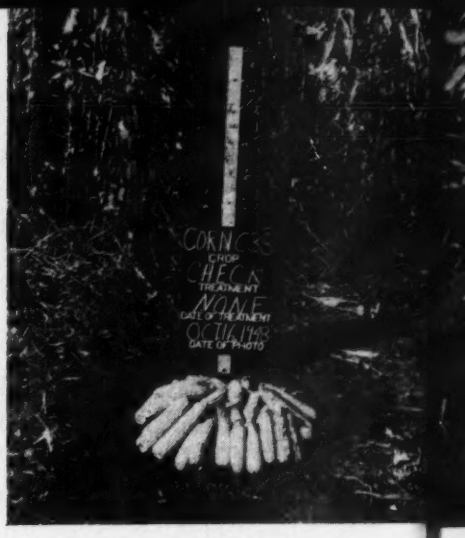
In these experiments, *the combination of moisture and nitrogen treatment improved quality and hastened maturity date.*

In Alabama, Pearson and Scarsbrook (1959) studied the nitrogen requirements of cotton at different levels of irrigation. Using *irrigation and liberal fertilizer treatment,* they produced nearly 5,000 pounds of seed cotton per acre, *more than twice the yield from either practice alone.*

They obtained an increase of 15 pounds seed cotton per pound of nitrogen for the first 120 pounds applied with the most frequent irrigation. The increased yields were 7 pounds per pound of nitrogen for the intermediate irrigation and 4 pounds without irrigation.

—CONTINUED ON PAGE 37

Untreated corn, heavily infested with weeds.



Treated corn received 2 lbs. 2,4-D per acre as pre-emergence spray.

Untreated corn plots produced average yield of 64 bushels per acre.

HOW WEEDS CAN REDUCE YIELDS AND QUALITY

By W. C. SHAW,
AGRICULTURAL RESEARCH SERVICE
U.S. DEPARTMENT OF AGRICULTURE

WEEDS have plagued man's efforts to produce food and fiber for as long as history has been recorded. To produce many of our most important crops is largely a battle with weeds.

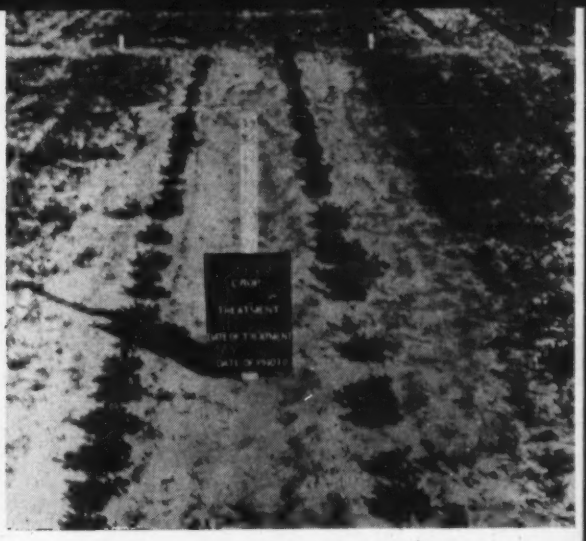
We know what happens to a cultivated field when it is abandoned, regardless of its productive capacity. Without man's efforts, it soon drifts into annual grasses and broadleaved weeds, then certain perennial grasses and sedges, broomsedge, pine forests, and finally into what is called climax-vegetation—that is, oak-hickory or beach-maple forests in the East, although climax-vegetation varies widely according to location.

In the face of this tendency by plant successions to return to a vegetation of weeds and trees, we are like a balancing act on a seesaw.

WEEDS COST FARMERS BILLIONS

Weeds cost American farmers an estimated 4 billion dollars annually. They compete with crops for water, light, and mineral nutrients. They increase the cost of labor and equipment, hinder mechanization of crop production, reduce quality and quantity of farm and livestock products, harbor insects and diseases, and im-

Corn plots treated with 2,4-D produced average yield of 103 bushels per acre.



Center peanuts received 9 lbs. DNBP per acre as pre-emergence spray, while flanks received none.

pair the health of livestock and humans.

Take corn, for example. The best tillage and cultivation we have developed controls only part of the weed populations in corn. The uncontrolled weeds produce seed that reinfest the soil annually.

Our total losses from weeds in corn exceed $440 million each year. (See table 1)

WEEDS ARE DAMAGING COMPETITORS

Weeds are tough competitors. For example:

1 One plant of common mustard (technically known as *Brassica kaber*) takes up twice as much nitrogen and phosphorus, four times as much potassium and water as a well developed oat plant.

2 Ragweed (*Ambrosia artemisiifolia*) takes three times as much water as corn does to produce one pound of dry matter.

How much weeds reduce your crop yields and quality depends on: (1) the composition of the weed population, (2) density of the population, (3) length of time the weeds are allowed to grow in competition with crop plants, (4) various soil properties and environmental conditions.

Weed competition is most serious during the first 30 days after weed emergence. You should either pre-

Table 1—Weeds Cost Corn Farmers Millions

	Cost
1 80 Million Acres Cultivated At Least Twice a Year Just to Control Weeds	$240,000,000
2 Weeds Not Controlled by Cultivation Reduce Yields Estimated 2 Bushels Per Acre	$200,000,000
Total Loss	$440,000,000

vent their emergence or control them immediately after they emerge. Weeds are luxuries no farmer can afford. The convincing way weeds compete with crop yields is illustrated on pages 35 and 36, showing how alfalfa and rice responded to herbicide treatments.

COMBINATION OF METHODS

To control weeds efficiently, you must use cultural, mechanical, biological, and chemical methods. Take rice, for a brief example.

Rice farmers are always faced with annual and perennial weed grasses, sedges, broadleaved weeds, and aquatic weeds. Research results on weed control in rice contain some useful lessons for nearly all farmers. These results suggest the use of a combination of cultural-chemical practices. There is not room to cite all the research results. But among some of the more important weed control practices are these:[1]

1 Use weed-free seed of adapted variety, prepare land efficiently, rotate crops, use adequate plant food, hand-pull many weeds, and initiate other practices peculiar to rice.

2 Cultivate repeatedly in the spring at 1 to 3-week intervals prior to seeding the rice, which usually reduces barnyardgrass and other weed infestations. The last cultivation is usually shallow to prevent viable weed seed from being brought near the soil surface. Seed rice on a roughly prepared seedbed to discourage germination of weed seed.

3 Carefully time applications of both phosphate and nitrogen: (1) Phosphate just before the rice is inundated the first time or to a crop other than rice in the rotation to prevent it from stimulating weeds in a dry seedbed; (2) Nitrogen at the time of the heading of barnyardgrass, because nitrogen applied while the weed grass is vegetative is used largely by the grass rather than the rice. They have found barnyardgrass and other weeds are stimulated by applying nitrogen before seeding of rice.

4 Use herbicides to supplement the cultural practices. CIPC is one of the most popular controls for barnyardgrass and other weed grasses in rice in certain areas. For post-emergence control of broadleaved weeds and sedges, they use several of the

Table 2. Rotation of Different Herbicides on the Same Crop [1]

		Chemical Weed Control Treatments	
Year	Crop sequence	Pre-emergence	Post-emergence
First	corn	simazine	2,4-D
Second	corn	CDAA+2,3,6-TBA	2,4,5-T
Third	corn	atrazine	2-(2,4-DP)
Fourth	soybeans	PCP	——

[1] Hypothetical rotation used to illustrate the principle of keeping maximum pressure on the weed population by the use of a series of herbicides which differ in their effectiveness in controlling various weed spectrums. This procedure reduces the chance of a species that is tolerant to a specific herbicide from becoming dominant. It also reduces the chance of an accumulation of herbicide residues in the soil.

phenoxyalkylcarboxylic acids—such as 2,4-D, MCPA, 2,4,5-T, and silvex.

TOTAL FARM PROBLEM

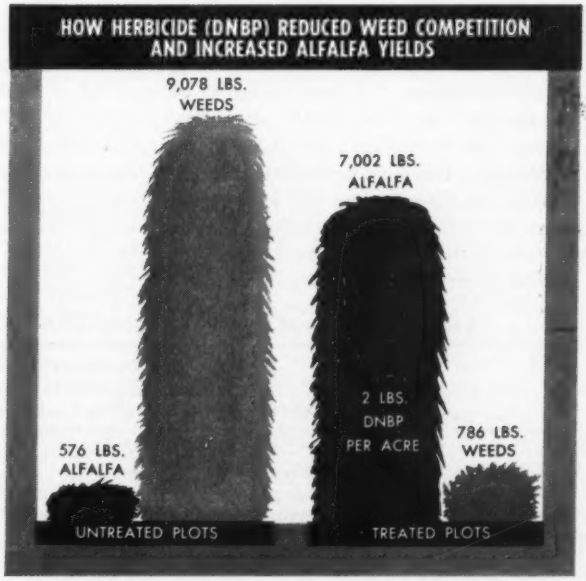
We must remember that weeds are a *total* farm liability because *all* crops on the farm are subject to their competition. Too often research scientists and producers alike approach the weed control problem only when the weeds are present in the current crop. When you go after weeds in the current crop only, the cost appears high. Farmers should be encouraged not only to use chemicals for controlling weeds on the current crop but also to rotate their use of herbicides on tolerant crops throughout the rotation in combination with various cultural and mechanical weed control practices.

For example, herbicides now used to control weeds in corn will not effectively control Johnsongrass in this crop. But the farmer can secure herbicides that will control Johnsongrass in alfalfa grown in *rotation with corn.*

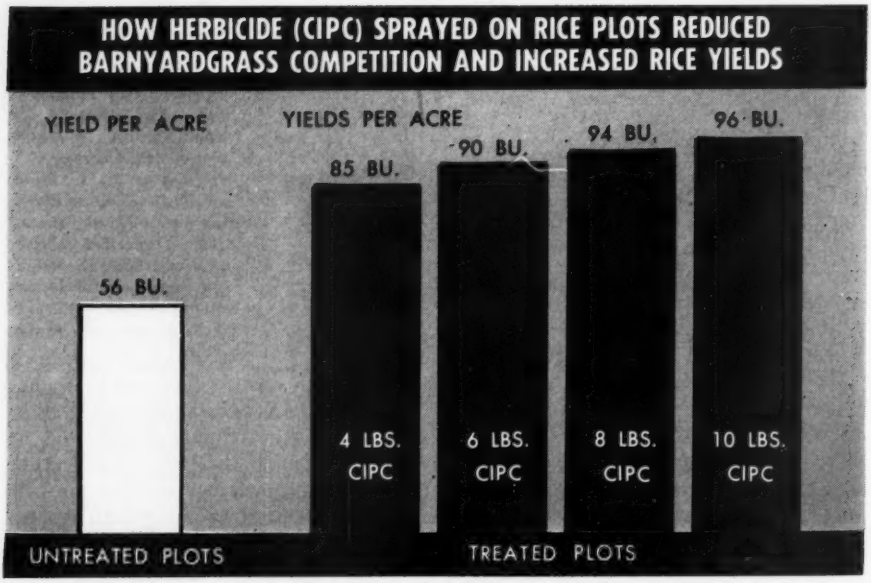
Many other annual and perennial weeds can be controlled effectively by using various herbicides on tolerant crops in the rotation.

Dr. Warren C. Shaw heads the Weed Control in Crops Section of the Agricultural Research Service, USDA, Beltsville, Md. An authority on weed control, Dr. Shaw earned his B.S. and M.S. degrees at N. C. State, his Ph.D. at Ohio State. His research has covered many important phases of weed control, including the effects of certain chemicals used to control weeds on major crops.

All good farmers know that a thoroughly prepared seedbed followed by clean, efficient, shallow, timely cultivation is important to weed control. They know there are no substitutes for adapted varieties, properly fertilized and managed. They know the value of rotating crops. What most of them must learn are the values of (1) rotational use of herbicides, (2) use of mixtures of herbicides, (3) multiple uses of herbicides in crop rotations combined with effective cultural and mechanical practices to control weeds. (See tables 2 and 3.)



The weed population consisted of 95% broadleaved weeds, including Bachelor's-Button, Hen-Bit, Vetch, and 5% grasses, including Italian Ryegrass and cultivated oats. DNBP did not effectively control weed grasses, so IPC was used to get good control of weed grasses. But IPC gave ineffective control of broadleaved weeds, resulting in only slightly increased alfalfa yields. Even better weed control and higher yields might have been obtained by using a mixture of both herbicides or a single herbicide effective on broadleaved weeds and weed grasses without injuring alfalfa.



HOW GOOD WEED CONTROL BUILDS FARM PROFITS

Cotton farmers can save $5 per acre —or $75 million annually—by applying efficient chemical weed control. For example, studies on cotton in Arizona, California, Georgia, and Mississippi showed that conventional methods (mechanical, cultural, and hand-hoeing) of controlling weeds cost $18.30 per acre and 27 man-hours. When herbicides were used to control weeds in cotton, the cost declined to $13.00 per acre and only 12 man-hours. That's a $5.30 per acre saving in dollars. But an even more striking saving in man-hours—15 hours—an important consideration as we face a decreasing supply of farm labor.

The interest of farmers in using herbicides for weed control has grown greatly in the past 5 years. In 1959, farmers used more than 100 million pounds of herbicides on approximately 50 million acres of agricultural land. The cost: $150 million. All the herbicides applied on this acreage were developed for commercial use in the past 10 years.

The future of weed control—and the profits it brings to farmers in the form of savings—depends on good extension programs to expand the usage of what is already available and good research work to develop new herbicides that will solve future weed problems as they arise. **THE END**

[1] *Smith, R. J., Viste, K. L., and Shaw, W. C. Progress in Weed Control in Rice Production in the United States. Proceedings International Rice Commission Working Party Meeting, Ceylon, December 14-19, 1959.*

Table 3. The Use of Various Herbicides on All Crops in a Rotation [1]

		Chemical Weed Control Treatments		
Year	Crop sequence	Pre-planting	Pre-emergence	Post-emergence
First	corn	EPTC	simazine	2,4-D
Second	peanuts	——	sesone	DNBP
Third	cotton	——	diuron	simetone
Fourth	soybeans	EPTC	PCP	——

[1] See footnote, Table 2.

WATER—CONTINUED FROM PAGE 31

The second 120 pound increment of nitrogen produced 9 pounds seed cotton per pound of nitrogen for the wettest irrigation, but this added nitrogen did not increase yields without irrigation or at the intermediate irrigation level.

Moisture supply and nitrogen fertilizer combinations have also produced yield increases of field corn in experiments in Oregon and Wisconsin, sugar beets in Utah and sugar cane in Hawaii, cotton in Mississippi and potatoes in Nebraska. Nitrogen and moisture seem to supplement each other, working together for greater yields than either factor gives alone.

But the effects of irrigation and phosphate fertilizer seem to be more independent than nitrogen and moisture. In Arizona experiments (Kelley 1954), alfalfa increased by 7.3 tons with improved irrigation at low soil phosphate over a three-year period. It also increased by 5.3 tons with phosphate under low moisture conditions. *The combined effects of water and phosphate fertilizer increased yield by 16 tons.*

Although *vegetative growth* of crops usually increases with available moisture, other components are often less sensitive.

For example, cotton *yields* have increased less from water experiments than the *leaves* and *stalks*. Similar results have been secured for seed of carrots, onions, and lettuce. Alfalfa seed yields reached maximum under dryer soil conditions than are needed for highest forage yields.

HOW ADEQUATE FERTILIZER HELPS YOU GET THE MOST OUT OF YOUR WATER SUPPLY

Since water is commonly a limiting factor we have emphasized practices that give the maximum yields for the water consumed.

The most effective practice is to increase soil fertility. Hanks and Tanner (1952) found that corn yield per inch of water consumed under experimental conditions in Wisconsin ranged *from 2.18 bushels under low soil fertility* to *3.87 under high fertility*. In other words, the more fertilizer applied the less water it took to get good yield.

Pearson and Scarsbrook (1959) found that the amount of water required to produce a pound of sudangrass in Alabama was cut almost in half by adding 100 pounds of fertilizer nitrogen per acre.

In Arizona, Stanberry, Converse, and Haise (Kelley, 1954) found that phosphate fertilizer treatments decreased the water used by alfalfa per ton of hay 33 per cent in the low soil moisture irrigation program and 45 per cent in the high moisture program.

In various studies on plant-water use, crops under frequent irrigations have used from 15 to 33 per cent more water than crops under low moisture condition. When adequate fertilizer has been combined with near optimum moisture, *yield increases* have ranged from *50* to *300 per cent.*

The result is a large net increase in water economy caused by fertilizer applications.

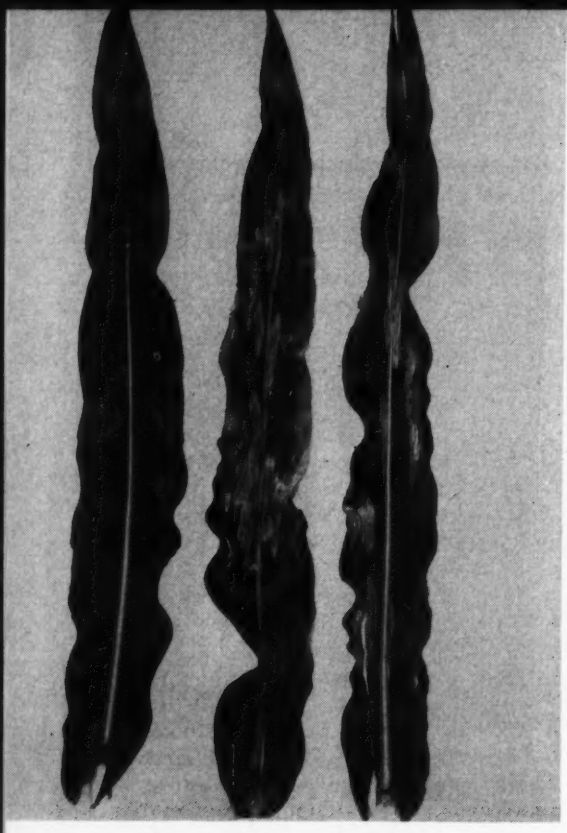
SOME WAYS TO CONTROL EVAPORATION

Evaporation steals much water that might otherwise be used for crop production. Mulches and other protective devices have been used in all parts of the world. Soil protection with stones has been used in China. Organic mulches (straw, etc.) are used.

A recent innovation are plastic sheets to cover the soil. This effectively controls evaporation and weeds.

Although we do not have all the answers, we now know how nearly to double our average yields *per unit of water consumed* by adjusting plant population, nutrient supply, planting dates, insect and disease control, and other factors to our water supplies.

THE END



A sample of northern leaf blight on corn.

PLANT DISEASES

ANOTHER FACTOR FACING THE FARMER

By
Earl K. Wade

University
of
Wisconsin

DID YOU know that most of the major field crops in this nation are subject to attack by *three or more* important diseases?

Did you know that the estimated financial losses from diseases of field crops is about $2⅓ billion annually—or 43 million acres lost?

No wonder a constant battle must be waged. No wonder continuous research must be conducted by plant pathologists to try to keep abreast of crop diseases and the damage they cause.

Such diseases as stem and leaf rusts, smuts, and seedling blights have cut small grain yields greatly, while corn leaf rust, stalk rots, and ear rots have robbed corn farmers of millions of dollars. Some examples of these losses are cited in table 1.

When you start totaling up these losses, the percentages run high. It's a multi-million dollar business loss to farmers. A problem affecting both yields and profits. A problem demanding attention because it is one of the farmer's serious limiting factors.

WHAT CAUSES MOST PLANT DISEASES?

Sometimes physiological disorders —caused by unfavorable soil conditions, temperatures, moisture supply, sunlight, and atmospheric humidity—are considered diseases in plants. But fungi, bacteria, nematodes, and viruses cause most of our plant diseases. And they are what we want to look at briefly here—at what they are, at some ways to prevent and control them.

Fig. 1 – SOME DISEASES AND THE CROPS THEY ATTACK

CROP	SMUTS	STEM RUSTS	LEAF RUSTS	LEAF BLIGHT, SPOTS	WILTS	ROOT, STALK ROTS, BLIGHT	DAMPING OFF SEEDLING BLIGHT	VIRUSES	NEMATODES	MILDE
LL GRAINS	●	●	●	●			●	●	●	●
N	●		●	●	●	●	●		●	
TON					●	●	●		●	
BEANS				●		●		●	●	●
	●			●		●	●			
NUTS				●		●			●	
		●			●		●			
AR BEETS				●		●	●	●	●	
ACCO				●	●	●	●	●		
LFA				●	●	●	●	●	●	
VERS				●	●	●	●	●	●	●
EDEZA				●	●				●	

. . . In a day when most field crops are subject to attack by three or more important diseases.

. . . When financial losses from field crops diseases totals nearly $2⅓ billion annually—or 43 million acres lost.

Fungi and Bacteria

They are tiny, microscopic plants that depend on green plants for their food because they do not produce chlorophyll themselves. They enter plants through wounds, natural openings, or directly through the epidermis or skin.

The various disease symptoms they produce include damping-off, molds, leaf spots, wilts, vascular discoloration, and rots of various kinds. They often live from one crop to the next on *plant debris* or remain alive in the soil as saprophytes.

Fungi, perhaps, are the best known organism causing plant diseases. In fact, out of the two billion different living things on earth, fungi compose approximately 80,000 to 100,000 species. Many of them have been turned to good use for mankind, in drugs, food supplements, certain cheeses, etc.

Viruses

These infectious particles are too small to be seen with the ordinary microscope. They can be seen through an electron microscope that magnifies them 10 to 20 thousand times or higher.

They are commonly transmitted from plant to plant by direct contact and mechanical means or by such insects as aphids, thrips, and leafhoppers.

Among the symptoms of virus are mottling of the forage, stunting, yellowing, irregular and distorted growth, leaf lesions, and actual necrosis or killing of the plant's tissue.

TABLE 1—HOW DISEASES CUT YIELDS AND PROFITS

SOME EXAMPLES

By some diseases . . .

STEM RUST

Reduced Durum wheat crop production over 31 million bu., threatening the Macaroni Industry.

In 3 years, cut Wisconsin's oat production 29 million bu. below "Normal".

VICTORIA BLIGHT

Attacked Victoria oat varieties so severely in 1946 and '47 that by 1950 few farmers in Wisconsin and neighboring areas were planting them.

CORN LEAF RUST

Cost Illinois, Kansas, Iowa, Indiana, South Dakota, and Wisconsin Farmer's $36 million —over 21 million bu.—in 1950 alone.

By some States . . .

OHIO

Farmers lose 17% of their $400 million corn crop to disease each year.

INDIANA

Corn Leaf Blight—50% Yield Loss
Stalk—2% Loss
Ear Rots—0.1% Loss
Smuts—0.1 to 1.0% Loss

IOWA

Corn:
Smut—8% of the Corn
Stalk Rot—5% of Corn
Ear Rots and Loss in Storage—10%
Root Rots and Seedling Blights—15%
Rust—0.1%
Leaf Blight—0.1%
Soybeans:
Disease took 12.6% of the Soybeans each year between 1951-58 . . . only 5.3% in 1959
Oats:
From 1926-1957, Disease averaged taking 21.4% of the Oats annually.
Alfalfa:
Between 1951-1957, Disease took 34.7% of the Alfalfa each year.

ILLINOIS (1959)

Oats:
Barley Yellow Dwarf reduced Production 44%.
Corn: ($70 million Lost to Disease annually)
Stalk Rot Reduced Corn Yield 16 to 20% Per Diseased Plant—About 4,500,000 Bu.
Ear Rots Cost Illinois Farmers about $1,500,000.
Leaf Blights strike about 5% of Cornfields in Southern Illinois, cutting production about 30%.

Nematodes

These are tiny slender worms just a bit too small to be easily seen by the naked eye. They are microscopic animals, not plants. Large numbers live in the soil. But relatively few species are known to be parasitic and, therefore, harmful to plants.

There are two types—soil nematodes and foliar nematodes. The soil worms either irritate the roots of plants or actually feed on them, causing weak, stunted plants. The foliar worms attack the plant above ground, causing stunting, malformation, and leaf spotting.

HOW TO PREVENT AND CONTROL DISEASE—A COMPLEX PROBLEM

This involves many factors. Some of the most important factors include:

Sanitation

Use uncontaminated or clean soil, compost, mulching materials, and tools. Rotate crops. Practice clean plowing. Prune off and remove diseased plant parts and dispose of this infected refuse properly. Try to prevent fungi and viruses from being transmitted on the hands of workers.

Right seeds and crop plants

Develop and use disease-resistant and disease-free seeds and crop plants. Tremendous strides are being made in the area of strong, healthy seed and crop plant varieties.

Insect Control

Control largely those insects that are vectors or carriers of virus diseases —insects such as aphids and leafhoppers. This requires some knowledge of what insects carry.

Moisture and temperature regulation

With field crops, of course, this is seldom possible, except through irrigation situations. But it is highly practical and important in controlling

diseases that occur in storage and transit.

Chemical Fungicide Materials

When most people think of fungicide chemicals for controlling diseases in crop production, they think of seed treatments, soil fungicides and fumigants, and foliage sprays and dusts.

SEED TREATMENTS

Most hybrid seed corn is treated with a seed protectant before being sold by producers. Wisconsin requiries that hybrid seed corn be treated before it is sold.

Such treatment helps (1) protect the seed and prevent seed rot, (2) destroy organisms on the surface of the seed, (3) fight seed infections that cause seedling blights in small grains. It is a cheap way to protect both dormant and germinating seeds against disease attacks.

SOIL FUNGICIDES AND FUMIGANTS

Using uncontaminated fields plus rotation is still the best approach when possible. But with field crops, especially, adequate rotation cannot always be followed. Often you have to use an old contaminated field. When you do, you must rely on soil treatments if certain disease problems develop.

We don't have the space to discuss the various chemicals and their technical value in such treatments. But we will list a few fungicides and fumigants that are helpful in fighting soil diseases that attack field crops:

Formaldehyde—an old, reliable chemical for certain diseases. *Chloropicrin*—successful against most soil fungi and nematodes. *Vapam and Mylone*—two newer materials with some promise on certain field crop diseases, as well as weeds and certain plant parasitic nematodes. *Terraclor*—which has been used to control soil borne diseases on such field crops as beans, cotton, clovers, alfalfa, and wheat.

Earl K. Wade is Extension Plant Pathologist of the University of Wisconsin. He earned his B.S. and M.S. degrees from Wisconsin. He is a member of Alpha Zeta and the American Phytopathological Society. He is also active in the Wisconsin Association Extension Workers and the American Potato Growers Association.

WEAPON AGAINST NEMATODES

Two widely used and highly effective chemical soil fumigants for controlling plant parasitic nematodes are *ethylene dibromide* (EDB) and *dichloropropene* (DD). You must inject these chemicals into the soil with special field equipment or a hand injector on small areas.

Be sure the soil temperature is at least 50°F. when you apply the fumigant. And let some time follow treatment before planting the crop. Newer chemicals for controlling nematodes in the soil—*Nemagon* and *Fumazone*—are now available and somewhat more flexible than EDB or DD in their use.

NEMATODES CUT PLANT'S ABILITY TO MAKE FULL USE OF FERTILIZER

Well-known nematologists, like Gerald Thorne of the University of Wisconsin, say accurate data can be secured from fertilizer-treated plots only if the plot has been properly fumigated to control any nematodes present.

Recent research by G. E. Wilcox and other co-workers at Louisiana Agricultural Experiment Station supports Thorne's contention. For example, a 4-year project showed:

(1) That a healthy, more vigorous

—CONTINUED ON PAGE 47

CORN STANDS

DON'T LET THEM BE YOUR LIMITING FACTOR . . .

. . . Like this poor stand

FOR TOP economic crop production, you must have adequate plant population. Inadequate crop stands can limit your yields and profits greatly. Over 50 years of research on stand and plant population support this fact.

Many factors, it seems, have caused most farmers to shy away from trying for high plant populations, especially in corn. Their objections seem to be:

1. Mechanical problems with corn planting equipment—not dropping as many viable kernels as the planter indicates at fast planting speeds.
2. Smaller ears that come with higher populations.
3. Increased lodging.
4. Increased number of barren plants.
5. Fear of decreased yields during dry seasons.

Many farmers who have accepted the idea have not secured higher plant populations or have suffered reduced yields because they failed to apply certain practices that must go along with increased stands.

By Gordon Ryder

CHECK CORN STANDS EASILY

To estimate number of seed dropped by planter, or to estimate your actual corn stand, measure off 1/1000 acre of row. Count actual seeds on stalks. Number equals number-per-acre in thousands. For example, with 40-in. rows, count numbers in 13 ft.-1 in., or about 4 long paces—that is, 16 kernels in 13' 1" of 40" rows =16,000 kernels per acre.

Row Widths	Length of Row Equal to 1/1000 Acre
40 inch	13 ft.-1 in.
38 inch	13 ft.-9 in.
36 inch	14 ft.-6 in.

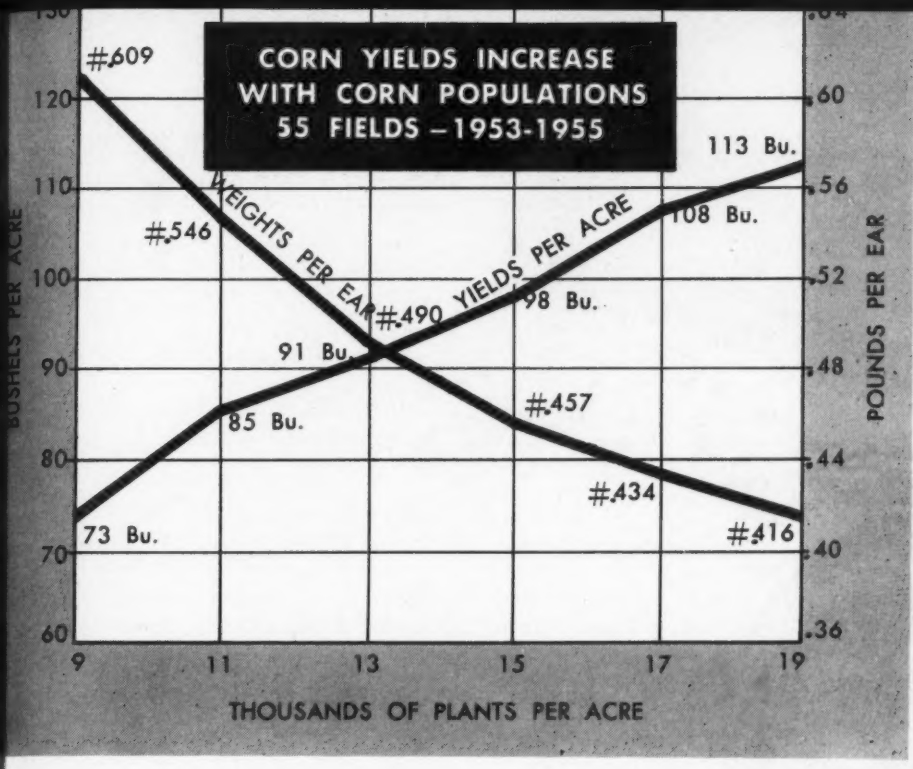


Figure 1—Remember: It's the bushels per acre—not the size of ears—that bring the profits.

To succeed at high plant populations, you should:

1. Keep your fertilizer rates in balance with anticipated yields.
2. Use proper seed plate, set planter to offset loss, control planting speed and rate.
3. Use hybrids that are adaptable to high populations—that is, hybrids with large root systems and strong stalks, with disease and insect resistance, with genetic traits for most efficient water use.

Failure to recognize and apply these complementary practices usually causes reduced yields. The farmer naturally blames the high populations and returns to his original practice of lower crop stands.

Ohio State University

HOW HIGH PLANT POPULATION PAYS OFF

For several years Ohio farmers have failed to secure high plant population because of mechanical problems with corn planting equipment. Figure 1 summarizes yield and plant population data from a series of dem-

ALLOW FOR FAST PLANTING SPEEDS

At fast planting speeds, most corn planters do not drop as many viable kernels as the planter settings indicate. For example, at only 5 to 6 miles per hour, unplanted or cracked seeds may cause a 10 to 15 percent stand reduction below the planter setting. This is in addition to losses from insects, diseases, or mechanical injury. The farmer seeking a final goal stand of 16,000 to 18,000 stalks should set corn planter for desired stand plus 10% for mortality.

TABLE I—HOW PLANTER SPEED AFFECTS SEED DROP

	Actual Kernels dropped per acre		
	Kernels per acre planter setting		
M.P.H.	12,000	16,000	20,000
3	12,800	16,300	19,500
5	12,500	14,300	17,500
7	11,400	11,500	11,500

onstrations using eight hybrids with four rates of fertility on 55 fields during 1953-1955.

Here is striking evidence that higher plant population pays off—in this case, *40 more bushels per acre.* The 9,000-plant stand produced 73 bushels while the 19,000-plant stand produced 113 bushels per acre. Nearly every corn producing state has reported similar experiences from well managed higher population stands.

In observing these results, note how the weight per corn ear declined as the plant population (and bushel yield) increased. The average ear weight decreased from .6 of a pound at 9,000 plants per acre to .4 of a pound per ear at 19,000 plant population.

That might disturb some farmers who judge corn yields on the basis of a crib of large uniform ears. But it is the *bushels per acre*—not the size of individual ears—that bring the profits.

TWO CAUSES OF STAND MORTALITY

In all these demonstrations, farmers and county agents were instructed to adjust corn planters for an 8″ seed spacing in 40″ rows which is a theoretical seed drop of *19,600 kernels per acre.* But the lower-than-desired stands typify many corn belt farms where farmers are attempting to secure high plant populations for top economic production.

This difference in stand between the *theoretical seed drop setting on the corn planter* and the *actual number of plants at harvest* has been called *plant mortality.* This so-called stand mortality can range from 15 to 25 per cent of the theoretical planter settings.

This decrease in stand is due to two factors:

1 *A reduction in the number of kernels planted due to mechanical failure or inadequate equipment.*

2 *The loss of plants from the time the viable seed is in the ground until harvest time.*

HOW SPEED AFFECTS STAND—TABLE I

Any decline in the accuracy of your seed drop is related directly to the r.p.m. (revolutions per minute) of your corn planter seed plate. Pull your corn planter faster or increase your planting rate and you automatically increase the r.p.m. of your seed plate.

Although some literature says new corn planters can be used up to 7-10 mph, your seed drop accuracy drops because the seed box has not been changed materially. Table 1 shows what effects planter speed had on three planter settings of 12,000, 16,000, and 20,000 kernels per acre. This shows what is happening in fields when planting speed or planting rate is increased. For example, if you set your corn planter to drop 12,000, 16,000, or 20,000 kernels per acre at only 3 m.p.h., you get a very accurate seed drop at each rate.

Increase your speed to 5 m.p.h. and your lowest planting rate (of 12,000 kernels) won't be off but about 300 kernels, while the two higher rates of 16,000 and 20,000 seed will be off 2,000 kernels each per acre.

When you pull the planter 7 m.p.h., you drop about the same number of viable kernels regardless of the

corn planter setting—11,400 at the 12.000-kernel setting, 11,500 (4,500 off) at the 16,000 setting, 11,500 (8,500 off) at the 20,000 planter setting.

When you increase your rate and speed from 12,000 kernels per acre at 3 m.p.h. to 20,000 kernels at 7 m.p.h., you quadruple the speed of your seed plate. And at these higher speeds, the kernels of corn apparently do not have time to drop into the seed cells of the edge drop plates, causing empty cells to pass the boot.

SELECT PROPER SEED PLATE—TABLE II

Part of this decrease is due to improper seed plate. Table II shows conditions found both on seed corn check stands and in field planting operation. The seed corn producer had recommended a seed plate with a cell length of 36/64ths.

On the check stand in the laboratory and on a corn planter at slow speed, seed drop accuracy for the 36/64th inch cell was 99% of the theoretical and for the 40/64th inch cell 104% of the theoretical. In both cases 16 cell seed plates were used, with a setting of 16,000 kernels per acre. In this lot of seed corn 96% of the kernels measured 36/64th inch long or shorter.

Note how the larger seed cell was more accurate at *lower speeds.* At 7 m.p.h. there was little difference due to the length of the seed cell.

A 44/64th inch cell was used in these trials, but the percentage of cracked kernels increased enough to make it impractical, although it was most accurate at 7 m.p.h.

At speeds exceeding 5 m.p.h., a 24-cell plate can be used on some planters in place of the 16-cell plate. This will reduce the seed plate's r.p.m. by 50% and increase seed drop accuracy for a constant planting rate.

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HOW TO SET PLANTER TO OFFSET LOSS

Planting speed, planting rate, and seed plate selection are only three of many factors affecting accuracy. For example, (1) there are slight differences in the size of cells in the same plate, (2) seed plate clearance in the seed corn box varies, (3) worn parts inside the seed box, weak knock-out springs, or worn knock-out parts all vary so much that every lot of seed corn should be checked in the field.

Check your kernel drop this way:

1. Select and install plate size recommended by seed corn producer and fill seed boxes.
2. Set corn planter for desired stand *plus 10% for mortality.*
3. Adjust planter to drop kernels on top of ground when in gear.
4. Pull the corn planter in a prepared seedbed at the normal speed of planting for 50-100 feet.

TABLE II—PLANTER PLATE CELL SIZE AFFECTS ACCURACY OF SEED DROP

Cell length	Percentage of cells dropping kernels		
	3 m.p.h.	5 m.p.h.	7 m.p.h.
	%	%	%
36/64th"	100	88	71
40/64th"	103	98	76

5 Measure and count kernels for each box—that is, 16 kernels in 13′ 1″ of 40″ rows = 16,000 kernels per acre.

6 Change forward speed, seed plates, and planter setting to secure intended seed drop.

STAND LOSS

The second group of factors which reduce stands includes plant mortality due to (1) poor germination, (2) poor seedling emergence, (3) insects, (4) diseases, (5) poor cultivation, and other losses.

The number of plants that die after planting depends greatly on management practices. On several hand-planted plots and plots thinned to known stands after emergence, stand loss has increased with increasing populations. The reduction ranges from about 5% at 10,000 plants to 15% at 24,000 plants per acre.

For plant populations ranging from 16,000 to 20,000 plants per acre, you can expect a loss of 8% to 10% of the plants between planting and harvest.

For a fertilizer demonstration in Miami County, Ohio, this year, farmers were asked to set corn planters for a 7-inch seed drop (*22,800 kernels per acre*) at planting time. The average number of plants harvested on the 48 demonstration fields was *17,600*. Stand counts taken shortly after emergence and again at harvest time in the same area showed a *9% plant loss*.

IDEAL STAND

There is no one ideal corn population for all America—or Ohio. Using Ohio as an example, most of our stands are too low for top economic yields or for most efficient use of fertilizer.

Harvest stands near 17,000 plants seem best in western Ohio where soil fertility-moisture relations are adequate for 100-120 bushels per acre.

In northern Ohio, the stands on comparable soils should be 18,000 to 19,000 for the shorter season varieties.

When the soil fertility-moisture conditions mean less corn yield potential the stand should be reduced about 2,000 plants for each 20 bushels below 100 bushels.

The ideal stand will become heavier as the stalk quality improves, as corn hybrids become less bare under crowding, and as fertility levels approach the ideal. **THE END**

DO *YOUR* EXPERIMENTS MISLEAD THE FARMER?

Uncontrolled limiting factors ruin a lot of experiments. This would not be too serious except for our tendency to use any data as the whole truth as long as it comes from a formal experiment, good or bad as it may be.

Let us abandon or make historic museums out of inadequate experiments and not use them as fences across the roads to progress. To use data in new literature from such experiments is not only misleading, but clutters our libraries and makes dead what can be inspiring and stimulating.

To conduct an experiment to determine the value of a specific factor, when one or more other factors may be the chief function defining the performance, is wasteful, erroneous, and *boring*.

(George D. Scarseth, American Farm Research Association, West Lafayette, Indiana)

DISEASES—CONTINUED FROM PAGE 41

root system developed in soils where parasitic nematodes were controlled.

(2) That corn, cotton, and sorghum yields were significantly increased by nematode control.

(3) That plants with healthy roots following soil fumigation used nutrients more effectively at a lower fertility level in the soil than plants having poor root systems because of nematode attacks.

When 50 pounds of N were added per acre, a marked increase in nutrient uptake occurred in the fumigated soil —from 41% for Ca to 82% for P. And increasing the nitrogen from 50 to 100 pounds on fumigated soil increased the uptake of K, Ca, and Mg, but not the P. When dolomitic limestone was added, the uptake of P, K, and Mg increased.

In other words, adequately fumigated soil enabled the corn to use the nutrients and moisture more effectively.

AVERAGE FIELD CROP NOT GENERALLY SPRAYED OR DUSTED

To be most effective, fungicide sprays and dusts should be applied at regular intervals throughout the growing season to protect the plant against possible attack—including such crops as vegetables, fruits, and other special crops. But the average field crop does not have a high enough value per acre to warrant such use. It is also difficult to spray or dust most field crops without causing considerable damage, unless aerial equipment is used.

In some parts of the country, regular applications of foliage fungicides are necessary and warranted. Field and sweet corn in Florida, for example, receive fungicide sprays to control leaf blight. It pays when conditions favor disease development and the field crop has a high acre value.

ERADICATING ALTERNATE HOST PLANTS

Certain plant diseases are controlled by getting rid of alternate host plants that carry the disease to valuable field crops. For example, we fight to eliminate the common barberry to control stem rust of small grains and work to eradicate the common buckthorn to control leaf rust of oats.

In 19 of the principal grain-growing states, barberry has been attacked by a cooperative federal-state program.

A good example of this cooperation has been the work on buckthorn, alternate host of oat leaf rust. In one section of Wisconsin, buckthorn was quite plentiful. Oat losses to leaf rust were heavy. Joining hands with the local county agent, town chairmen, weed commissioners, and the county highway department, college specialists have been able to destroy much of the buckthorn in the area. The result: great reduction in early and severe oat leaf rust infections.

PLANT QUARANTINES

Because plant disease organisms can be transported on plant host parts or with non-host carriers, quarantine regulation can be effective. Most states practice plant quarantine, through the Federal Plant Quarantine Act of 1912, when the need arises.

For example, a federal quarantine was placed on wheat and wheat products from India, Japan, China, Australia, South Africa, Italy, and Spain to prevent Wheat Flag Smut from being brought into this country.

The same practice is observed between states, at times. Federal and state inspection of harvested crops before they are sold helps control crop diseases. Certified seed agencies over the country also help control disease and reduce crop production losses.

IN SUMMARY

Obviously plant diseases are a serious limiting factor in crop production. Prevention and control require intelligent use of recommended practices by the grower. **THE END**

In Conclusion . . .

sm
editor

WE HOPE this special issue has been helpful to you and has given you some idea of the many factors constantly challenging the farmer in his efforts to produce enough food for a rapidly growing population.

In it, the authors have shown the farmer some of the important factors that determine the profits he makes—or does not make—on the crops he produces. Weather he cannot control, except to a degree through irrigation and drainage. But he *can* select land most suitable for the type crop he wants to grow. He *can* control insects that harm or eat up his crops. He *can* eliminate weeds that compete with crops for water and nutrients. He *can* supply his crops with sufficient amounts of the right kind of plant food to produce a profitable crop.

In it (perhaps unknowingly) the authors have also shown the farmer's city cousins—those 88% of the nation's taxpayers who have done much to perfect mass production and quality control—what it means to mass produce and control quality outdoors in the face of insects, diseases, droughts, rains, weeds, winds, poor soil, low stands, etc.

In their factories and business houses, these city cousins can control the temperature, disease doesn't exist, the routine is pretty well set. But have they ever scheduled a corn seed to burst out of the soil the morning *after* the last spring frost?

Down their assembly lines skilled technicians keep the bugs out and the finished product comes out in the end ready to sell, sharp as a tack. But have they ever walked down a corn row burned by drought or infested with borer or stunted by leaf blight?

Meeting production deadlines is achieved through efficient management and teamwork, planning, budgeting, scheduling their costs and profits so the profits will mean something at the end of the year. But have they ever

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met a 90-day maturity deadline for a sensitive vegetable crop or rushed to install irrigation, to save an expensive crop, only to have soaking rains flood its rows the morning after?

They feed their machinery a certain fuel and it runs and produces and serves them well—over and over and over. But have they ever fed plant food to a soil only to have the crop unable to use it due to faulty application machinery or too much or too little rain?

Their production is usually very systematic, the same bolt turned the same distance, the same package sealed the same way—by the hundreds, by the thousands. But have they ever worked one day repairing a tractor transmission, another building a new fence, another operating a corn harvester, another auditing financial records, another taking soil samples for testing their land?

Although certain interests have attempted to paint the farmer as a rather greedy heifer sucking hard on mama-government, we still contend that farming is the most complex business in the world—and the farmer a remarkable businessman after all.

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